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MAY 1977

PROTOTYPE WASTE RETRIEVAL SYSTEM-CONCEPTUAL DESIGN

FINAL REPORT

FOR

ATLANTIC RICHFIELD HANFORD COMPANY
FEDERAL BUILDING
RICHLAND, WASHINGTON 99352

PaR Job No. 5004

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ABSTRACT

The conceptual design for a Prototype Waste Retrieval System is described. The System is comprised of remotely-operated equipment for removing defense wastes from underground storage tanks on the Hanford Reservation. In addition to recovering the waste from the tanks, the equipment will package the waste into reusable containers, load the containers onto transport tractor-trailers and safely move the containers to a processing facility on the Reservation. Waste recovery (mining) tools are mounted on an articulated mining boom which enters the storage tank through a 42-inch diameter riser. Waste is removed from the tank by an elevator which operates through a second 42-inch riser. The System includes a shielded and sealed filling room in which shipping containers receive the waste from the elevator bucket. Containers are moved into and out of the filling room on a turntable equipped with shielded air locks. An overhead crane handles containers between the turntable and the tractor-trailer. Other components of the System are: mining-tool change machine, TV viewing and lighting units, wash-down equipment, ventilation unit, control center trailer, on-board maintenance facilities and safety monitoring instrumentation. The waste retriever is mounted on track-type transporters to facilitate moving between tanks without dismantling and reassembly. The System has an average waste material rate of 598 gallons per hour and, if operated on an average of two 8-hour shifts per day, will remove approximately 3.5 million gallons per year.

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ACKNOWLEDGEMENTS

The conceptual design of a Prototype Waste Retrieval System for recovering defense wastes from underground storage tanks at the Hanford Reservation which is described in this report was done for the Atlantic Richfield Hanford Company (ARHCO) by Programmed and Remote Systems Corporation, (PaR).

PaR would like to acknowledge the many contributions and fine support provided throughout the project by ARHCO and the U.S. Energy Research and Development Administration (ERDA). Among the key people at these organizations who participated in the project are:

ARHCO, Hanford Waste Engineering

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The individuals at PaR who participated in the project include:

Dennis D. Gorman
Marvin W. Lee
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Curtis B. Londroche
Donald F. Melton
Karl E. Neumeier
Marvin A. Sandgren

We at PaR have enjoyed working on this project and believe that it has resulted in a conceptual design which can contribute to the Hanford program for long term management of defense high level waste.

PaR accepts the responsibility for any errors or omissions in the conceptual design or this report.

Programmed & Remote Systems Corporation
Marvin A. Sandgren
Engineering Project Manager

Donald F. Melton
President

1.0 INTRODUCTION

In support of the Hanford Long-Term High-Level Waste Management Program, Programmed and Remote Systems Corporation (PaR) has conducted a design study of a remotely operated Prototype Waste Retrieval System for removing solid waste from the underground storage tanks on the Hanford Reservation. The work has been performed under Consultant Agreement CA-190, Prime Contract E (45-1)-2130, with the Atlantic Richfield Hanford Company (ARHCO), Richland, Washington.

The basic concept of an articulated mining boom capable of entering a 42-inch diameter tank riser was developed during the initial study effort which ran from April, 1975 to November, 1975 and is covered by a PaR report dated 11 November 1975. Work was resumed in July, 1976 under Supplement No. 1 to Consultant Agreement CA-190 (Prime Contract EY-76-C-06-2130). Thus, the design for the Prototype Waste Retrieval System described herein is a further development of the same basic overall concept which was described in the first report.

This second report presents the specifications and design considerations as well as a complete discussion of the prototype design.

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a tank and can be placed into an operating configuration in a fully filled tank.

Tools are removed from and placed on the outer end of the boom by a tool change machine. Tools are stored in racks which can be reached by the tool change machine or a two-ton crane. The tools are the items which will become the most contaminated. Each time a tool is removed from the boom by the tool change machine, it is moved to a wash station between the mining boom room and the maintenance room. After washing, the tool can be returned to its storage rack or into the maintenance room for repair. The maintenance room has an overhead monorail hoist and a floor mounted tool maintenance cart for handling tools during washing and maintenance. With the tools washed, contact maintenance can be performed on them. The maintenance room has side doors through which tools and other items can be delivered and shipped, and a storage area for spare components.

A personnel room next to the maintenance room has lockers and showers for maintenance personnel. A personnel corridor running the length of the main structure allows viewing and local control of all operations. Shielded windows are provided for viewing.

Waste material picked up by the boom is moved to an elevator which operates through a 42-inch diameter riser located 20 feet 9 inches from the tank centerline. The elevator, mounted in a tower similar to the mining boom, carries material deposited by the boom up into a shielded filling room within the structure. A bucket on the elevator is pivoted to a position over a shielded shipping container (shipcon) used to transport material to the processing plant. The bottom of the elevator bucket is opened and the waste material placed in the shipping container.

2.0 SUMMARY (Ref: Figures 2-1 and 2-2)

This report covers the conceptual design of a Prototype Waste Retrieval System for use in removing defense wastes from underground storage tanks at the Hanford Reservation.

The basic requirements of the System are that it be able to remove all of the waste material contained in the tanks and package it for shipment to a processing plant on the Hanford Reservation in a safe and cost effective manner.

The System described meets the basic requirements as well as the numerous other specifications and criteria which are involved. The Prototype Retrieval System conceptual design is shown on Figures 2-1 and 2-2.

The retrieval equipment is housed in a T-shaped structure which spans a tank so as to not impose loads on the tank dome. Tracked, powered transporters at each of the three ends of the structure are used to move the waste retriever from tank to tank.

Waste material is removed from a tank by means of an articulated, hydraulically actuated mining boom which operates through a 42-inch diameter riser in the center of the tank dome. The boom is mounted to the bottom end of an electrically powered telescoping hoist which travels within a tower located in the center of the waste retriever structure. The tower includes a boom washing system. The boom can be withdrawn from the tank for tool changing, maintenance, and moving between the tanks. A variety of remotely interchangeable tools used to remove pipes and other obstacles from the tank, break up hard waste material, move waste material to an elevator and perform the final tank clean-up are located in an area adjacent to the boom. The boom with its tools can reach any location within

Shipping containers are moved into and out of the filling room by a turntable which passes through two shielded air locks. These provide shielding and air restriction between the filling room and the unshielded shipping and receiving room. Each shipping container, received by trailer from the processing plant, is inside a sealing container (sealcon) which provides double containment during transport. The sealing container never enters a contaminated area. The containers, which are washed prior to leaving the processing plant, are removed from the trailer by a 20-ton crane which services the System shipping and receiving room. The crane removes the lid of the sealing container, lifts out the shipping container and places it onto the turntable. After the shipping container is moved to the filling station next to the elevator, a lid handling machine removes the lid and moves it to a storage position. When the shipping container is filled, the lid handling machine replaces and latches its lid and the turntable moves the filled container into the wash station. After the washed container is moved to the shipping room, the overhead crane places the shipping container into the sealing container, places and latches the lid on the sealing container and places them on the trailer for transport back to the processing plant. The trailer is 10 feet wide and has a latching and energy absorbing mounting to secure the containers to the trailer. The turntable method of moving shipping containers into and out of the filling room provides a production method of operation to provide a maximum continuous amount of waste material throughput. Three shipping containers are in process simultaneously within the waste retriever, one being loaded onto or off of the turntable, one being filled and the third being washed.

A Model 3000 manipulator, which runs on the same rails as the two-ton crane, is stored in the maintenance room. By means of remotely operated doors, the manipulator can be moved into the mining boom room and the filling room to accomplish various maintenance and clean-up tasks. For example, periodically the manipulator is used to remotely operate wash water hoses installed in the filling room and mining boom room for washing down the equipment, walls and floors in these rooms. Floor drains return the water to the wash water system.

Air pressure within the System is maintained at a slight negative gage pressure by a ventilation unit mounted over a small diameter riser in the tank. A standby diesel generator is provided to keep the ventilation system operating in the event of a main power failure. These measures minimize the possibility of radioactive release from the System.

In-tank viewing is provided by television cameras and lights mounted on vertically positionable supports which extend into the tank through small diameter tank risers.

Television cameras also are provided for viewing of remotely-controlled operations performed in the above-ground portion of the System.

The primary control center for the Prototype Waste Retrieval System is in a trailer located near the main structure.

All of the equipment of the System can be controlled remotely from this control center. Human engineered controls and displays provide convenient, efficient operation. A mini-computer is used to operate the System in an automatic mode. This assures a maximum continuous operation rate and reduces operator fatigue and chance for error.

A power center room is located in the main structure.

General features incorporated in the Prototype Waste Retrieval System conceptual design include:

- Provisions for continuous, all weather operation are included. Working areas are heated, cooled and lighted as required.

- No water is put into waste tanks. All water used in washing boom tools and shipping containers is used to flush the elevator bucket and thus is placed into shipping containers and sent to the processing plant.

- Instrumentation is included as required. Radiation monitors and pressure and temperature sensors are located at appropriate places and displayed in the control center.

The Prototype Waste Retrieval System conceptual design presented in this report meets the requirements for a functional, safe, cost effective means of removing defense waste material from underground storage tanks and shipping it to a processing plant.

It is believed that the conceptual design fully meets the intent and requirements of the contract under which it was done and provides the basis for further work leading to a demonstration system.

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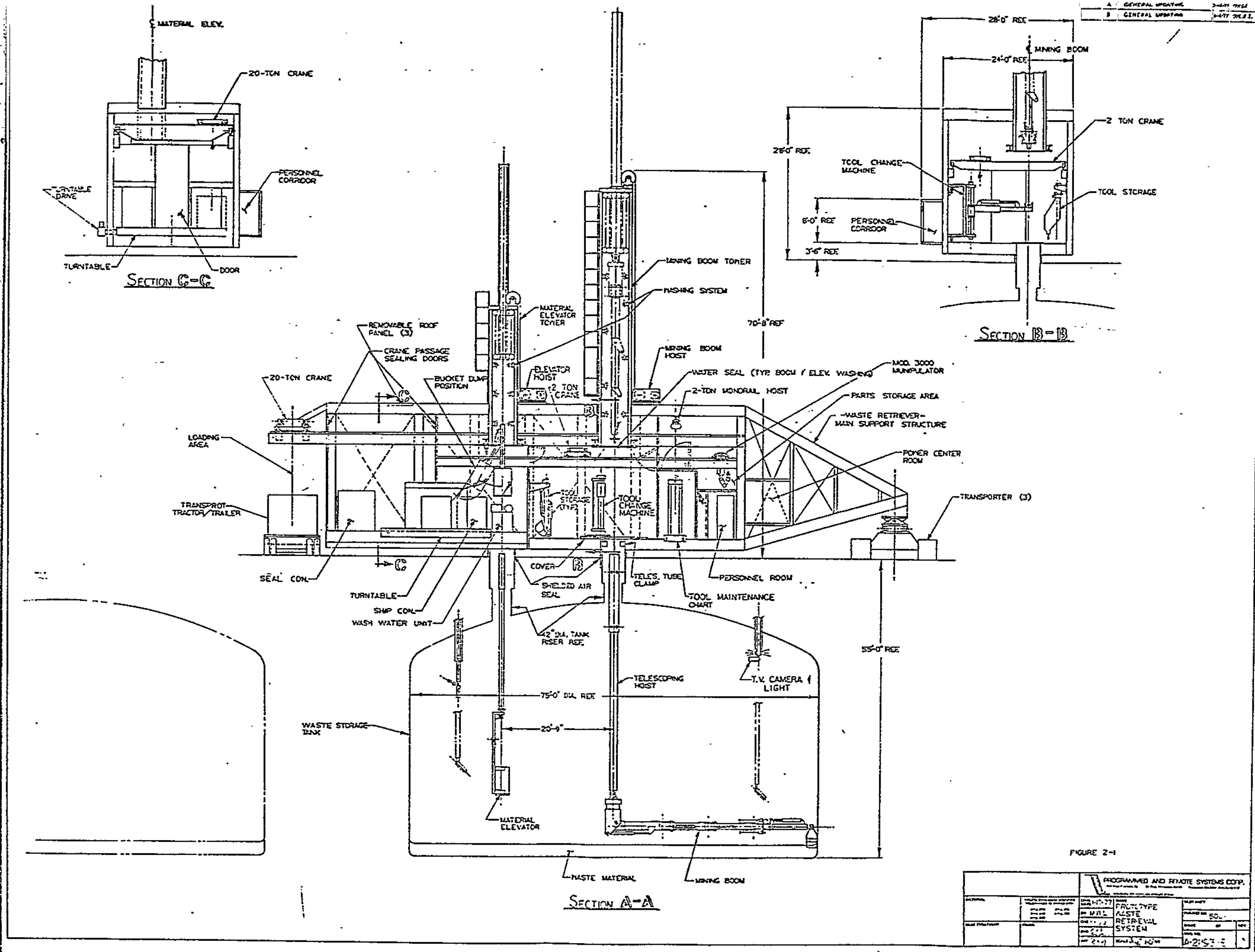

MATERIAL ELEV.
20-TON CRANE
PERSONNEL CORRIDOR
TURNTABLE DRIVE
TURNTABLE
DOOR
SECTION C-C
28'-0" REF
MINING BOOM
24'-0" REF
2 TON CRANE
TOOL CHANGE MACHINE
TOOL STORAGE
PERSONNEL CORRIDOR
6'-0" REF
3'-6" REF
SECTION B-B
MINING BOOM TOWER
WASHING SYSTEM
MATERIAL ELEVATOR TOWER
REMOVABLE ROOF PANEL (3)
CRANE PASSAGE SEALING DOORS
70'-8" REF
MINING BOOM HOIST
ELEVATOR HOIST
12 TON CRANE
BUCKET DUMP POSITION
20-TON CRANE
WATER SEAL (TYP. BOOM / ELEV. WASHING)
MOD. 3000 MANIPULATOR
2-TON MONORAIL HOIST
PARTS STORAGE AREA
WASTE RETRIEVER-MAIN SUPPORT STRUCTURE
LOADING AREA
POWER CENTER ROOM
TRANSPROT-TRACTOR/TRAILER
TOOL STORAGE (TYP)
TOOL CHANGE MACHINE
TRANSPORTER (3)
SEAL CON.
COVER
TELES. TUBE CLAMP
PERSONNEL ROOM
TURNTABLE
SHIELDED AIR SEAL
TOOL MAINTENANCE CHART
SHIP CON.
WASH WATER UNIT
42" DIA. TANK RISER REF.
55'-0" REF
TELESCOPING HOIST
T.V. CAMERA & LIGHT
75'-0" DIA. REF
WASTE STORAGE TANK
20'-9"
MATERIAL ELEVATOR
WASTE MATERIAL
MINING BOOM
SECTION A-A
FIGURE 2-1
PROGRAMMED AND REMOTE SYSTEMS CORP.
PROTOTYPE WASTE RETRIEVAL SYSTEM
A GENERAL UPDATING
B GENERAL UPDATING

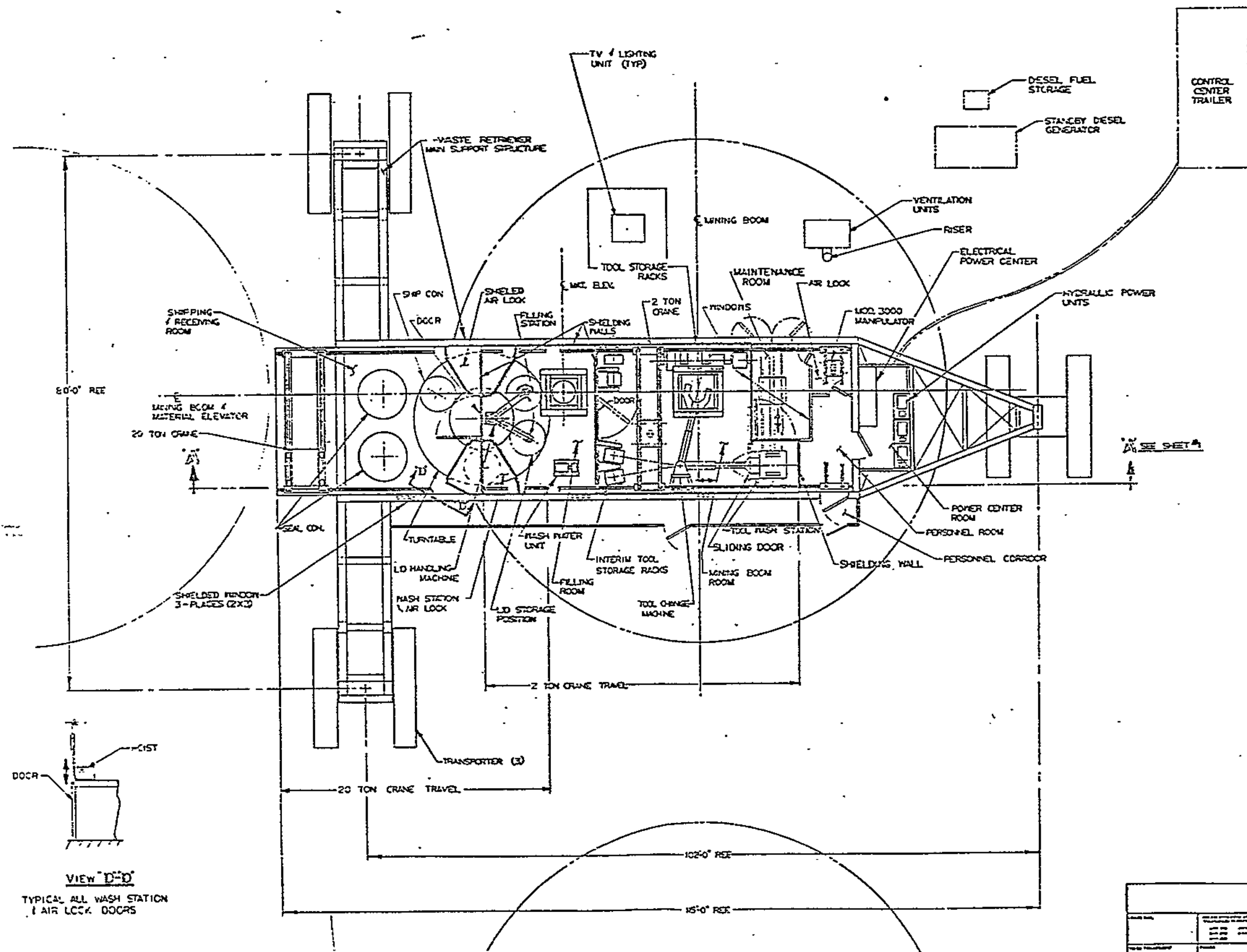

FIGURE 2-2

PROGRAMMED AND REMOTE SYSTEMS CORP.

3.0 STATEMENT OF WORK

The effort expended in preparation of this report and the conceptual design described herein was performed under Supplement No. 1 to Consultant Agreement CA-190 which contains the following statement of work.

Statement of Work

Contractor shall develop the conceptual design of a functionally complete and integrated Prototype Waste Retrieval System based on the in-tank subsystems conceptually designed in the recently completed portion of Consultant Agreement CA-190. This design shall be the result of engineering studies of alternative concepts developed on the basis of performance requirements established by ARHCO.

In the progress toward this ultimate goal, Contractor shall evaluate alternative solutions and assure necessary subsystem integration for each aspect of the total waste retrieval problem. This problem is defined as the removal of all solid waste material (including interstitial liquid), as well as in-tank obstruction and debris, in a safe, efficient, and cost effective manner from all Hanford waste tanks containing said material. The scope of the retrieval operations shall include, in addition to the retrieval machinery, items and considerations such as: tank site prepartions; utilities requirements; safety; decontamination; maintenance and repair; system relocation; waste packaging, handling, and transportation, etc.

The work to be accomplished hereunder shall progress in accordance with the tasks as follows:

Task 1- Contractor shall analysze information from ARHCO on tank configurations and material content, as well as proposed operational procedures, and incorporate this information into conceptual designs for each subsystem and component of a waste retrieval system. Emphasis shall be on subsystem and component performance with assurance of safe, efficient, and cost effective operation.

Task 2- Contractor shall continue engineering studies of the in-tank subsystems (articulated arm, material elevator, and television viewing and lighting systems) in light of additional conditions and revised criteria supplied by ARHCO. Emphasis shall continue to be on performance and reliability, with additional studies being directed toward retrieval tool change and subsystem maintenance and repair capability and procedures.

Task 3- Contractor shall develop a complete conceptual design of the Prototype Retrieval System. This conceptual design shall consider all aspects of retrieval operations and include all features necessary and appropriate for safe, efficient, and cost effective retrieval and transport of Hanford high-level wastes.

Task 4- Contractor shall provide informal progress reports in the form of minutes of discussion meetings between ARHCO and Contractor personnel. These meetings shall occur at approximate one-month intervals or as required to assure continued progress. Contractor shall issue preliminary reports in the following sequence: WASTE RETRIEVAL SYSTEM-IN-TANK SUBSYSTEMS at the end of month five; WASTE RETRIEVAL SYSTEM-CONCEPTUAL DESIGN at the end of month seven. Contractor shall conclude this contractual agreement by furnishing ARHCO with a WASTE RETRIEVAL SYSTEM-CONCEPTUAL DESIGN, FINAL REPORT which summarizes the accomplishments of Tasks 1 through 3.

4.0 SPECIFICATIONS & DESIGN CONSIDERATIONS

The matter of defining the design requirements for the Prototype Waste Retrieval System, of necessity, has been a continuing processs throughout the conceptual design effort. This has been true for the work performed under the original Consultant Agreement CA-190 as well as under Supplement No.1. The following paragraphs contain a summary of the specifications or design considerations which are applicable to the Prototype Waste Retrieval System.

4.1 PROTOTYPE RETRIEVAL SYSTEM REQUIREMENTS

A complete waste retrieval system shall include the following elements:

- Mining equipment to remove waste material from the tank and move it to the surface. This equipment shall include a remote controlled boom operating remotely interchangeable mining tools, and an elevator to move the waste to the surface. The mining tools shall include means of breaking up hard layers of waste, removing in-tank obstructions, moving material to the elevator and performing final tank clean-up.

- A surface loading facility to package or prepare the retrieved waste for transport to an onsite processing facility or storage area.

- A means of transporting the waste to the processing facility or storage site.

- Equipment to allow movement of the retrieval system from one tank to another.

- A facility for the decontamination and maintenance of the retrieval equipment.

- A remote controlled video system with suitable lighting to enable the equipment operator to visually observe the retrieval equipment operating in the tank.

- A control center from which all operations can be controlled and monitored.

The waste system shall be designed so as to satisfy the following general design criteria:

- The retrieval equipment shall be remote controlled with no personnel access allowed inside the tank at any time.

- The retrieval system shall be capable of being moved from tank to tank. Nominal center-to-center distance between adjacent tanks is 102 feet.

- Access to the tank interior shall be through 42-inch diameter risers which penetrate the tank dome. For the prototype design, it may be assumed that a tank has two 42-inch risers, one on tank centerline and one located 20 feet 9 inches from the center. Smaller risers will be available for installing video equipment and lighting for remote observation.

- The main retrieval equipment shall not be mounted directly to any riser or impose any direct loads on any riser.

- The retrieval equipment shall be capable of removing waste from any point inside a waste tank below the liquid level line. The inside diameter of the tanks is 75 feet. The maximum distance from ground level to the bottom of a tank is 55 feet. With the exception of the A tanks, the minimum distance from the bottom of the central riser to the level of the salt cake is 12 feet 7 inches. The minimum distance at the 20 foot 9 inch radius is 10 feet 2 inches. The A tanks have central risers extending 25 feet into the tank.

- The retrieval equipment shall be capable of mining around in-tank obstructions or removing them.

- The minimum rate of waste retrieval shall be 500 gallons per hour. This rate is the equipment operating rate before compensation for operator efficiency, downtime for maintenance, etc.

- All equipment used in a contaminated or potentially-contaminated areas shall be designed for maximum reliability, maintenance, and ease of decontamination.

- The retrieval system shall minimize, to the extent practicable, the amount of radioactive material discharged to the environs from the retrieval operations. This requirement applies to the shipping containers as well as the system structure.

- The main structure of the retrieval system shall be made in sections which can be readily hauled to the site and bolted together using conventional field erection techniques.

- The retrieval system shall be designed with adequate safety features to protect operating personnel from injury or exposure to hazardous radiation.

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- The air circulation and filtering unit with a standby power generator shall be provided as an item not incorporated in the main system structure. This ventilation unit shall connect to a tank riser not dedicated to the waste retrieval process.

4.2 WASTE CONSIDERATIONS

The retrieval system shall be capable of removing all waste material stored in specified underground tanks at Hanford. Radioactive waste to be removed is of two main types, salt cake and sludge. The consistency of the salt cake can vary from a dense pourable slurry to a cake product approaching the hardness of poor quality concrete. Salt cake has a tendency to form around any in-tank piping, resulting in large hard salt deposits around the pipe. These deposits are called "lollipops" and can weigh up to several tons. The consistency of the sludge is generally a dense pourable slurry. If the overlaying liquid is pumped off, the sludge can form a hard surface layer. An average density of 1.7 gm/cc for the waste material shall be used for design purposes.

In addition to the above waste forms, the tanks also contain miscellaneous debris such as rocks, bottles, pipe sections, sludge weights, small tools, section of riser covers, construction materials, gloves, plastic bags,etc. This debris is included in the waste that the retrieval system must remove from the tank.

The level of radioactivity of the waste varies, being higher for the sludge than for the salt cake. When removing high-level sludge, the amount of material loaded into a shipping container shall be reduced, if necessary, in order to maintain the total radioactivity within an acceptable level. This level is to be defined at a later date. The retrieval system shall be capable of monitoring the radiation level.

The retrieval system shall also be capable of measuring and recording, on a continuous basis, the amount of waste material being shipped from the tank site.

4.3 IN-TANK OBSTRUCTIONS

The SX, A, AX, AY and AZ tanks have air lift circulators and associated piping and supports which constitute in-tank obstructions to the waste removal process. The main portion of a circulator is a vertical standpipe two feet to two feet six inches in diameter and from ten feet to twenty-two feet long, either mounted on the tank floor or suspended from the tank dome. The retrieval system shall be capable of cutting these circulators into suitably sized pieces which can be elevated to the filling room and loaded into shipping containers as is done with the waste material. Piping which shall be removed, ranges in diameter from 3/4 to 6 inches.

The central 42-inch risers on the six A tanks extend down into then tank to a distance of 25 feet below the dome. If the level of the stored waste is at or near the bottom of this riser, the retrieval system must be capable of removing enough of the riser to allow the mining boom to gain entrance and be deployed in the normal operating position.

4.4 FACILITY CONSIDERATIONS

Following are ARHCO specifications and standards for tank farm operations that will apply to a waste retrieval system operating in a tank farm.

a. Hydrogen-Gas- The amount of hydrogen gas present in the vapor space of a tank shall not exceed 2 percent by volume; 1 percent is the standard.

b. Dome Loading- The maximum allowable live load on the dome of a tank is 46 tons (i.e. a 28-ton crane carrying an 18-ton load); 37 tons maximum is the standard.

c. Vapor Space Pressure- The vapor space pressure shall not go below -6 inches water gage or above +60 inches water gage; -3 inches to +20 inches is the standard.

d. Hydrostatic Head (minimum)- At least 6 inches of waste or water shall be present in the tanks at all times. If a tank is emptied, the tank vacuum must not exceed -3 inches water gage.

e. Heat Generation Rate- The heat generation rate of the stored waste shall not exceed 75,000 Btu per hour.

f. Temperature (maximum)- 325 degrees F, in the SX farm; 300 degrees F in the A, AX, AY, and AZ farms; and 230 degrees F in all others. The temperature given is the average for all points covered by waste.

g. Operating Temperature- The vapor space temperature inside a tank can be limited to 120 degrees F by an adequately sized ventilation system. The concentration of any combustible gases that might be present can be reduced to an acceptable level by the same method.

h. Temperature Gradient- 5 degrees F per day for in-tank temperatures of 180 degrees F or less. For temperatures over 180 degrees F, the maximum allowable gradient is 3 degrees F per day for heating and 5 degrees per day for cooling.

i. Shielding- On waste containers or transfer tanks,it shall be sufficient to limit the dose rate to not more than 200 milli-rem at the surface and not more than 10 milli-rem at 3 feet from the surface (reference DOT 49CFR 173.393).

5.0 SYSTEM GENERAL DESCRIPTION (Ref. Figures 2-1 & 2-2)

The Prototype Waste Retrieval System conceptual design is shown in Figures 2-1 and 2-2. The System includes all of the equipment required to safely and efficiently remove waste material from an underground storage tank and deliver it to a processing plant.

The System is made up of:

a. Waste Retriever
b. Ventilation and Air Monitoring System
c. Television Viewing and Lighting System
d. Control Center
e. Shipping and Sealing Containers
f. Transport Tractor/Trailer

The Waste Retriever, the major item of the Prototype Waste Retrieval System is discussed in this section. Component parts of the Waste Retriever and other parts of the System are discussed in more detail in following sections of this report.

The Waste Retriever provides equipment capable of entering a tank through a 42-inch diameter riser, picking up waste material and moving it to an elevator, raising the elevator through a second 42-inch diameter riser, dumping the material into a shipping container, capping and washing the shipping container, placing the shipping container into a sealing container and loading the containers onto a special tractor/trailer for transport to the processing plant.

The Waste Retriever is divided into several operational areas. These rooms and the equipment in each are:

Mining Boom Room

This area is involved in the operation of the mining boom and mining boom tools.

The equipment in this room includes:

Mining Boom
Mining Boom Tools
Tool Storage Racks
Tool Change Machine
Two-Ton Crane
Tool Wash Station
Mining Boom Wash Station

Shipping and Receiving Room, and Filling Room

These areas are involved in receiving containers from the processing plant, filling the shipping container with waste material removed from the waste tank, capping and washing the shipping container, placing it in a sealing container and delivering the waste material in the container set to the processing plant.

The equipment in these areas includes:

Material Elevator
Material Elevator Wash Station
20-Ton Crane
Turntable
Shielded Air Locks and Wash Station
Lid Handling Machine

Maintenance Room

This area is used for maintenance of the mining boom and tools and for receiving, storing and shipping components and spare parts.

The equipment in this area includes:

Tool Maintenance Cart
Two-Ton Monorail Hoist

Personnel Room and Corridor

These areas provide personnel access to the Waste Retriever for equipment maintenance and observation of operations.

The personnel room includes a shower, radiation monitoring equipment and an air lock into the maintenance room.

The personnel corridor runs the full length of the Waste Retriever. Windows into the operating areas and local equipment controls provide direct viewing and operation of all functions.

Power Center Room

This area includes the primary electrical and hydraulic power equipment required to operate the Prototype Retrieval System.

Access to this room is from the personnel room.

Some equipment, used in more than one room of the Waste Retriever, includes:

Special Handling and Viewing Provisions

Provisions are included for special situations such as initial erection, maintenance, moving between tanks and direct monitoring of operations.

These provisions and equipment include:

Model 3000 Manipulator (stored in Maintenance Room)
Inter-Cell Doors
Removable Roof Panels

Special Utilities Systems

These provide the water and air required to wash and dry components of the Waste Retriever and waste containers.

This equipment includes:

Wash Water System
Air Heating System

The following sections discuss the major items and provisions of the Prototype Waste Retrieval System.

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6.0 MAIN SUPPORT STRUCTURE (Ref: Figures 2-1, 2-2, 6-1)

Because of load limitations over the dome of the tank, the waste retriever is housed in a structure which bridges the tank. As seen in the plan view, the total structure is in the shape of a "T". Two points of support are at the ends of the "T" arms to provide stability and to make the end of the main structure accessible by truck. Thus, the structure is supported at three points and can be moved,via transporters, over uneven terrain without being subjected to warping as would be encountered with a four-point support arrangement. The structure is of truss construction to provide maximum rigidity at minimum weight. Walls, floor, and roof paneling and shielding are attached to the structure to enclose the waste retriever.

The enclosed tower which supports the mining boom telescoping tube and carriage assembly is mounted on top near the center of the structure such that the mining boom operates through a 42-inch riser in the center of the tank. A hoist mounted at the base of the tower handles the wire rope used to lower and raise the mining boom. An external safety ladder on the side of the tower is provided for access to the cable sheaves on top of the tower.

A second enclosed tower which supports the material elevator telescoping tube and carriage assembly is centered 20 feet 9 inches from the center of the mining boom tower. This tower is also equipped with a hoist and access ladder.

The enclosed portion of the structure is 22 feet wide and 76 feet long (inside dimensions). The floor is approximately 42 inches above ground level, and there is an 18-inch clearance between the bottom of the structure and the ground. The inside height of rooms is 22 feet.

At the entrance for personnel to gain access to the maintenance area there is a personnel room and an air lock. The ceiling height in these rooms is 8 feet so that storage space for spare parts and supplies is located overhead.

Support rails are provided for two overhead cranes. A 20-ton crane services the shipping and receiving room and a 2-ton crane services the mining boom room. The maintenance room, has a 2-ton monorail hoist. A side door is provided to move items into and out of the maintenance room. Waste material shipping containers are moved in and out of the structure through a large door at the shipping cell end by means of the 20-ton crane. Removable roof panels are provided to permit lifting heavy equipment components in and out by means of a truck crane.

The basic structure is shown conceptually on Figure 6-1. The sides, top and bottom of the working areas are fabricated from structural steel members in the form of trusses. Diagonal tension members are used to provide rigidity. The inside of the working area structure is left open to accomodate the equipment it will house. Smaller structural members will be used between the basic members shown, to support the walls, floor and roof, which will be fabricated in the form of panels.

The tapered structure shown on the right end of the plan and elevation views of drawing Figure 6-1, is a box truss which connects the working area structure to the tracked transporter connection point.

The T structure shown on the left connects the working area structure to the connection points for the other two transporters.

The structure will use bolted construction.

The entire structure will be shop fabricated and assembled, including walls, floors, roofs and the operating equipment. After shop testing, the system will be dismantled and shipped by truck to the operating site at Hanford Reservation. Using a truck-mounted crane, the system will be unloaded and re-assembled.

The general re-assembly sequence will be as follows:

- place longitudinal floor beams on leveled wooden shoring to provide ground clearance
- bolt in place the following:

  lateral floor beams
  wall columns and diagonals
  longitudinal crane support and roof beams
  lateral roof beams and diagonals
- install secondary support structure, floor, and walls and roof
- install major equipment items in working areas (sections of roof can be removed to accomplish this)
- assemble the tapered and T transporter connection sections and bolt to the main structure
- assemble the mining boom and elevator towers and bolt to the main structure
- install the mining boom and elevator
- connect the three transporters
- install and complete the required subsystems: hydraulic, electrical, instrumentation, etc.
- connect the control center trailer, which will be factory assembled and delivered to the site ready for use, to the Waste Retriever.

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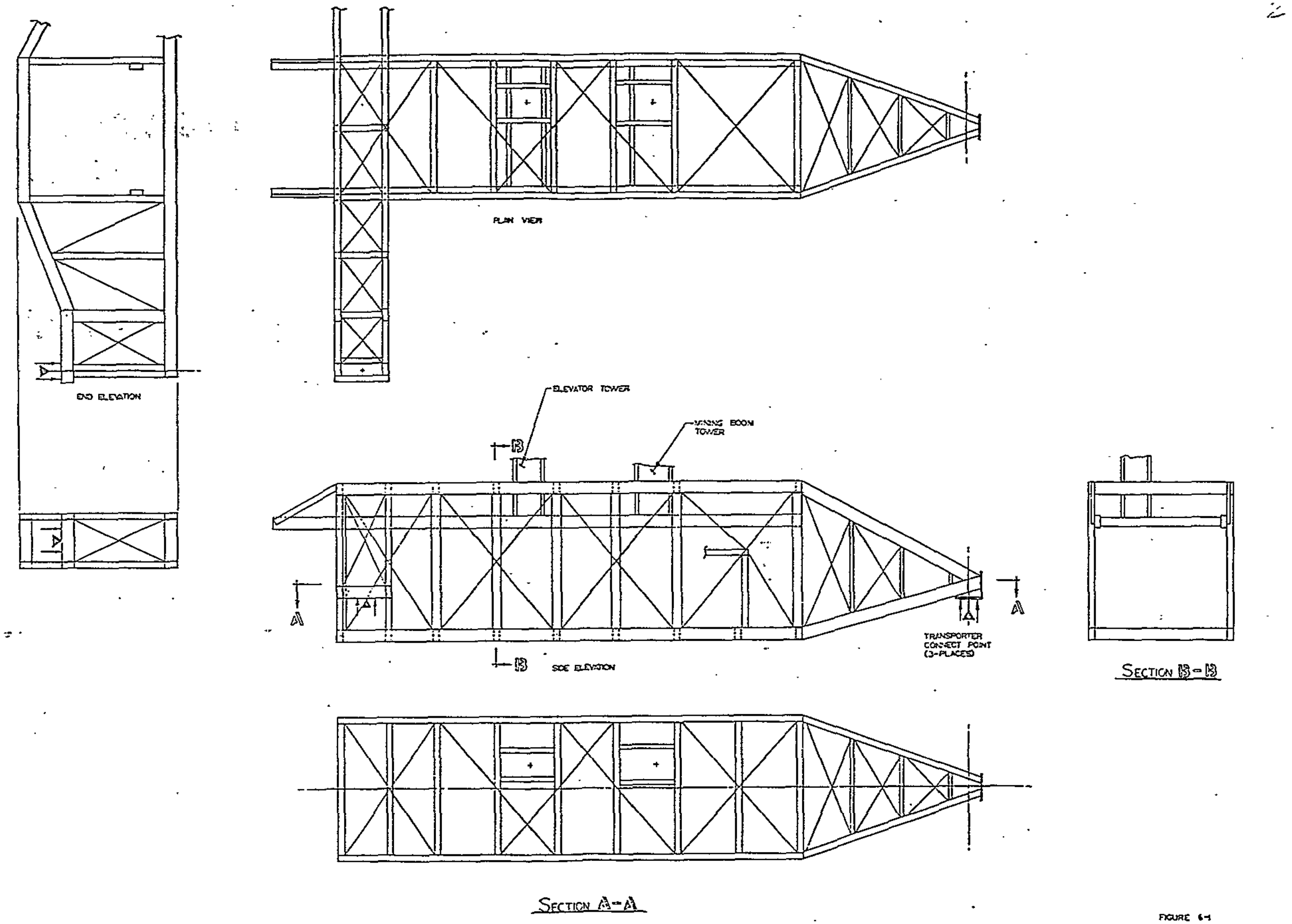

FIGURE 6-1

PROGRAMMED AND REMOTE SYSTEMS CORP.

MAIN SUPPORT STRUCTURE

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7.0 MINING BOOM ROOM EQUIPMENT

7.1 MINING BOOM (Ref: Figures 7-1 and 7-2 thru 7-17)

The mining boom is mounted at the lower end of a telescoping tube assembly which is supported in the mining boom tower. The tower is situated on top of the main structure over the central 42-inch riser in the tank. The mining boom enters the tank through this riser. As shown on Figure 7-1, the mining boom has four pivot motions and one rotate motion. These motions are hydraulically powered.

Each major section of the mining boom is 8 feet 7 inches long and has a travel of 100 degrees (from in line to right angle) relative to the section to which it is attached. The end section of the boom has an additional motion of 100 degrees used for positioning the mining tools which are mounted on the tool adapter incorporated on the end section. Each tool is made with its own boom which provides additional pivot and rotate motions for final positioning of the tool.

A model of the boom was made to test and demonstrate its motions and coverage. Some pictures of the model with boom sections arranged to show various configurations are presented in Figures 7-2 through 7-17.

Figure No.	Configuration
7-2	Boom extended-main pivot down 30 degrees - tool boom down 60 degrees-(A 12" scale shows the size of the model).
7-3	Boom extended horizontal-tool boom down 60 degrees.
7-4	Boom extended horizontal- tool boom up 40 degrees.
7-5	Boom horizontal- inner intermediate side pivot at 90 degrees- outer side pivot at 90 degrees.

Figure No.	Configuration
7-6	Same as 7-5 with tool boom up 40 degrees.
7-7	Boom horizontal- inner and outer intermediate side pivots at 90 degrees.
7-8	Boom horizontal- outer boom and inner and outer intermediate side pivots at 90 degrees.
7-9	Boom horizontal- outer boom at 90 degrees- tool boom down 60 degrees- inner and outer intermediate side pivots at 100 degrees. This figure shows the ability of the boom to work under the centerline of the telescoping tube hoist.
7-10	Same as 7-9 with tool boom up 40 degrees.

A series of pictures was taken to show how the boom is inserted into a tank through the central 42-inch riser. These are presented in Figures 7-11 through 7-17 which accompany the following text.

The procedure for placing the boom into a tank with a minimum headroom of approximately 12 feet, is as follows:

a) Figure 7-11 — The boom is in the full up position with all elements in line vertically.

b) Figure 7-12 — The telescoping tube hoist is lowered until the first side pivot joint from the outer end is about a foot below the bottom of the riser. The outer element is raised to the 90 degree position. The 100 degree up and down pivoted outer section is left in the in-line position throughout the process.

c) Figure 7-13 — The tube hoist is lowered until the next pivot joint is below the riser. As this joint is actuated to the 90 degree position, the outer section is returned to its in-line position.

d) Figure 7-14 — The process is continued for the next joint. At this time the three outer sections are horizontal with their pivot axes horizontal.

e) Figure 7-15 — The tube hoist is lowered until the innermost pivot joint is below the riser. The axis of this joint is 90 degrees to the axes of the other main pivots. Actuating the inner boom 90 degrees, rolls the boom to where the pivot axes of the outer main elements are vertical. This figure shows the inner boom pivot in an intermediate position between vertical and horizontal.

f) Figure 7-16 — The inner boom pivot is at the 90 degree horizontal position placing the side pivots and the outer up and down pivot in their operating positions.

f) Figure 7-17 — With the inner side pivot straightened, the boom is at its maximum reach position and the placement sequence is completed. By rotating the boom about the telescoping tube hoist vertical axis and the actuation of the boom main elements, the end of the outer boom can reach any position in the tank.

Removing the boom from the tank is done in the reverse sequence.

The operation of the mining boom is as follows:

a) The proper tool is installed prior to placing the boom in the tank.

b) A digging pattern is established to provide the easiest and most efficient boom usage. This generally will be the pattern which requires the fewest repetitive motions. One such pattern would be to extend the boom fully and dig a channel around the periphery of the tank. On the next pass, the outer boom would be pivoted to remove the material adjacent to the channel. This pattern would proceed inward until the entire layer is removed.

c) The telescoping hoist is lowered and the next layer removed. Since the various strata in the tank consist of different materials and may require different digging tools, the ability of the boom to remove all of one stratum, minimizes the number of tool changes required.

d) The control system has a provision to move the outer end of the boom to the material elevator and back to the digging location automatically. This eliminates the need of the operator to manually control the repetitive transport motions.

When material near or behind the elevator is being removed, the elevator can be raised to provide a clear work area and it can be rotated to place the elevator bucket in the best loading orientation.

Mining and cutting tools mount to the outer end of the boom by means of standardized tool adapters. Among the tools are a clam-shell digger, an impact hammer for breaking up hard materials, a back-hoe type digger and a cut-off tool and handling tool to remove pipes and other structural obstructions, and a special tool to perform the final cleaning of the tank walls and bottom.

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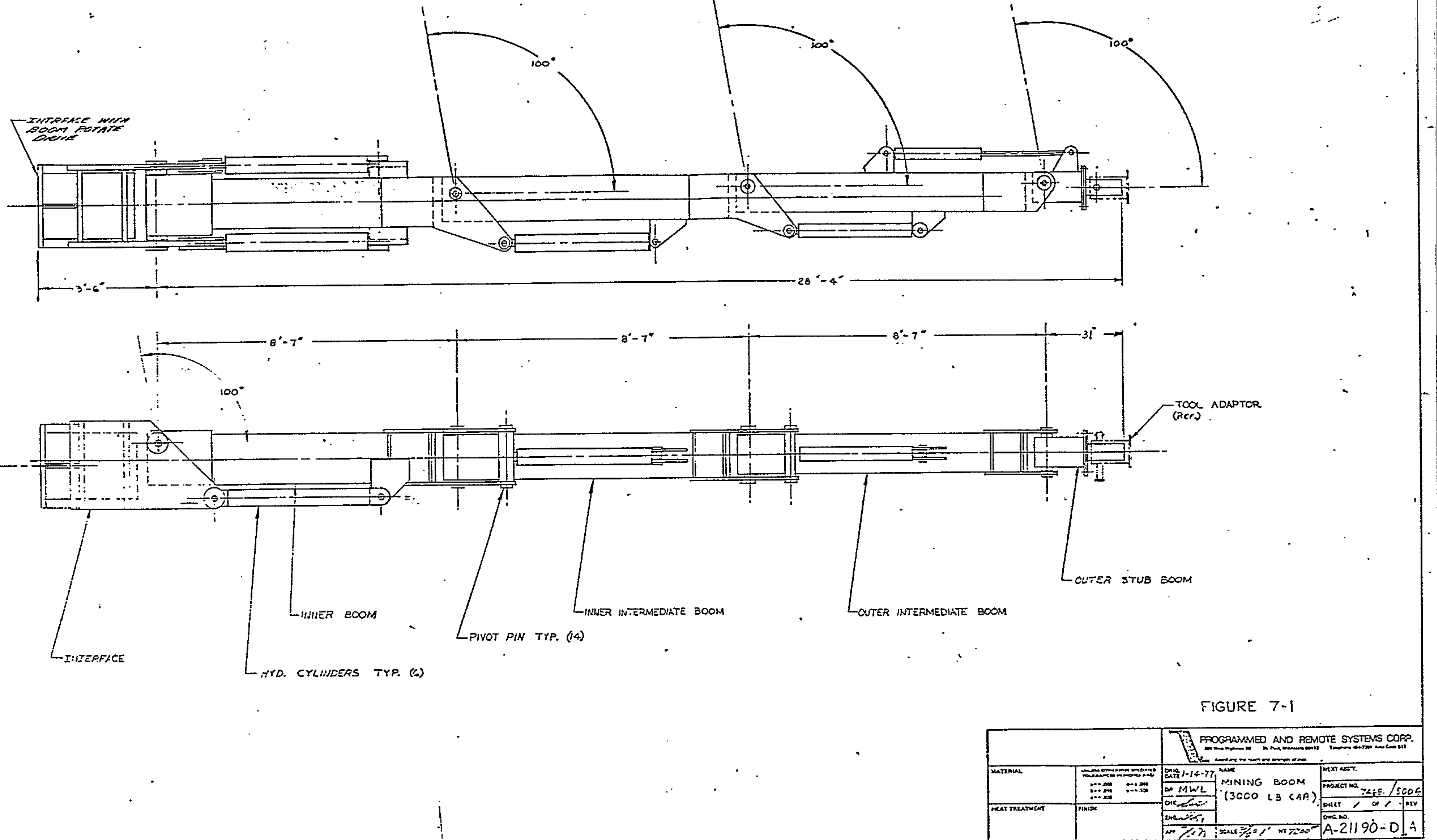

FIGURE 7-1

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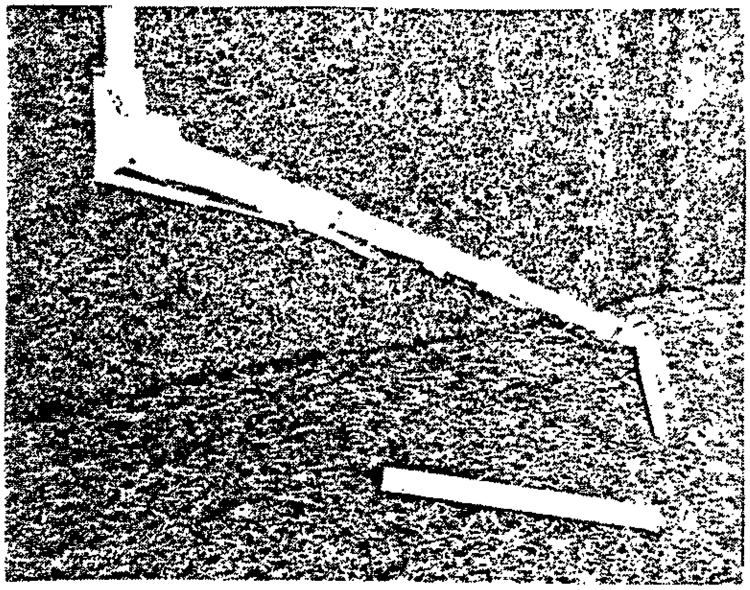

Figure 7-2

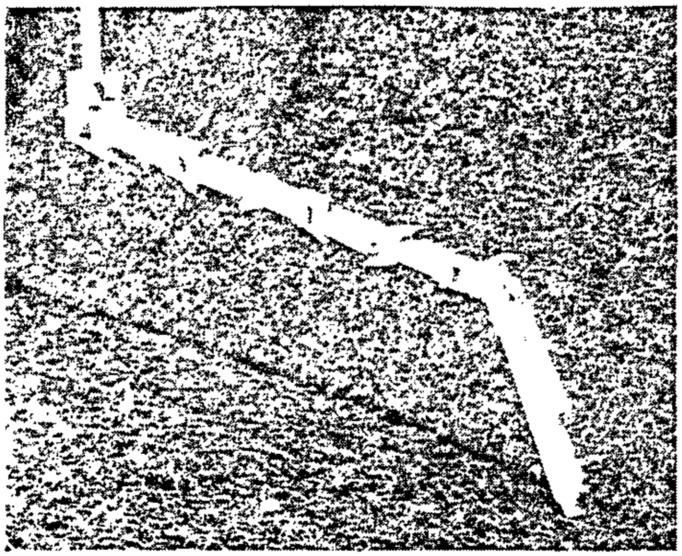

Figure 7-3

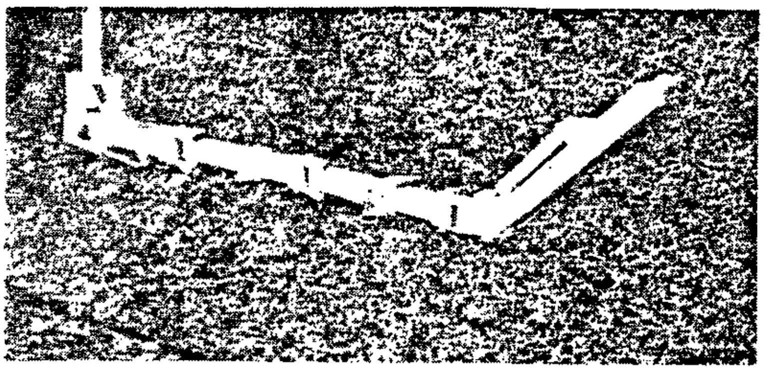

Figure 7-4

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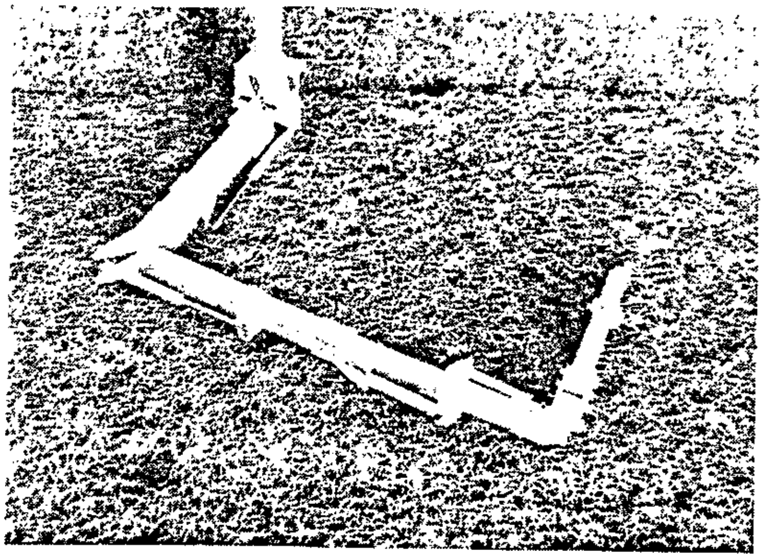

Figure 7-5

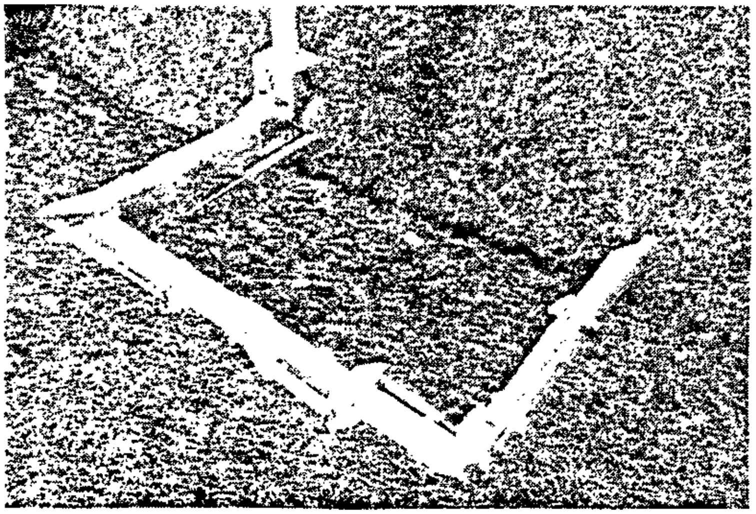

Figure 7-6

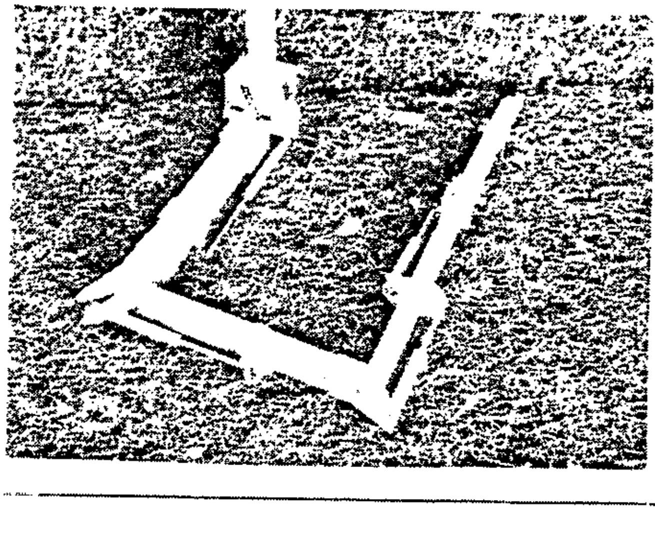

Figure 7-7

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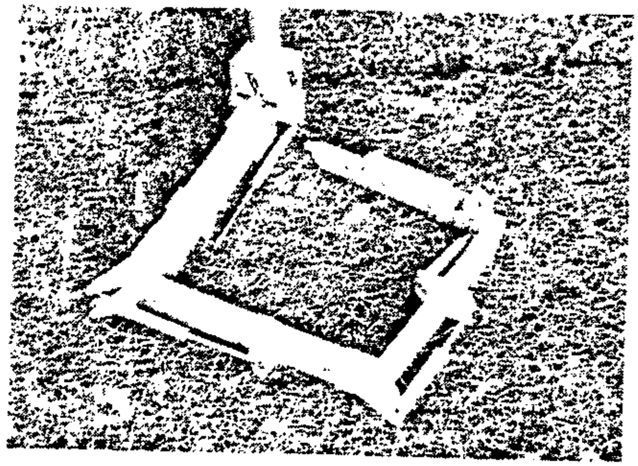

Figure 7-8

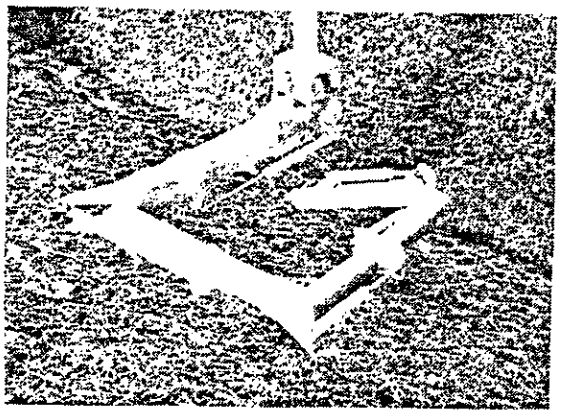

Figure 7-9

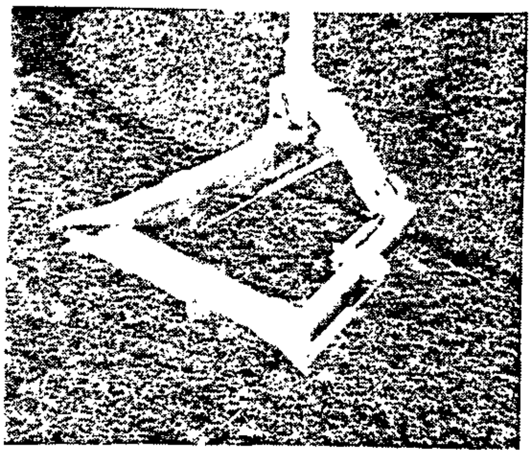

Figure 7-10

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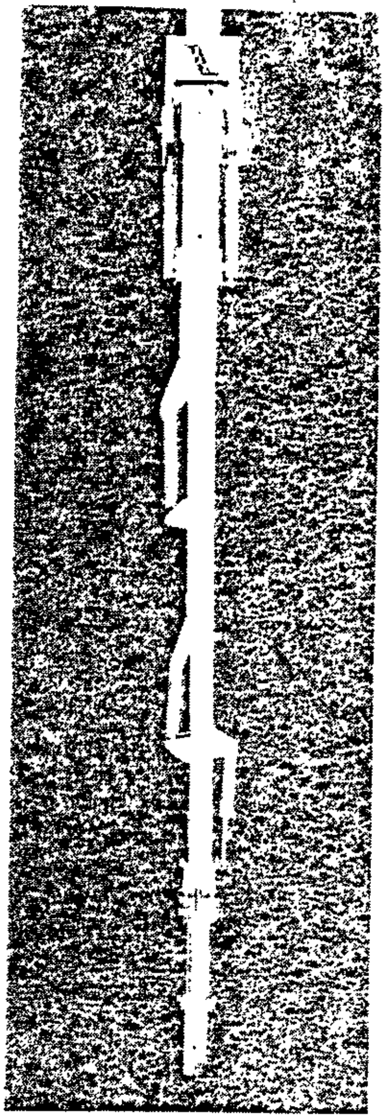

Figure 7-11

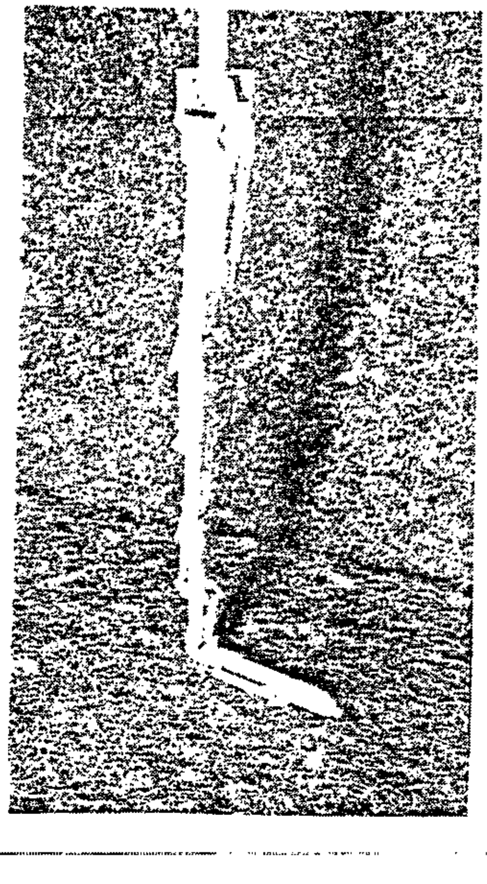

Figure 7-12

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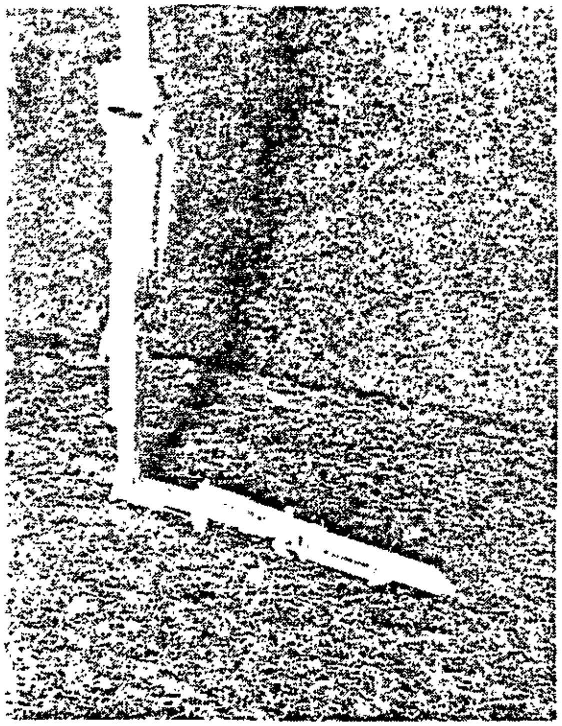

Figure 7-15

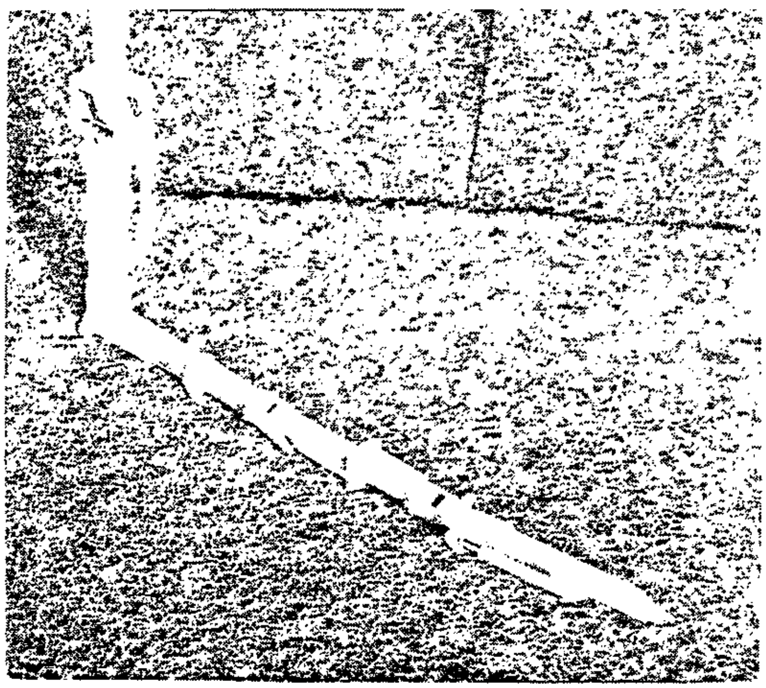

Figure 7-14

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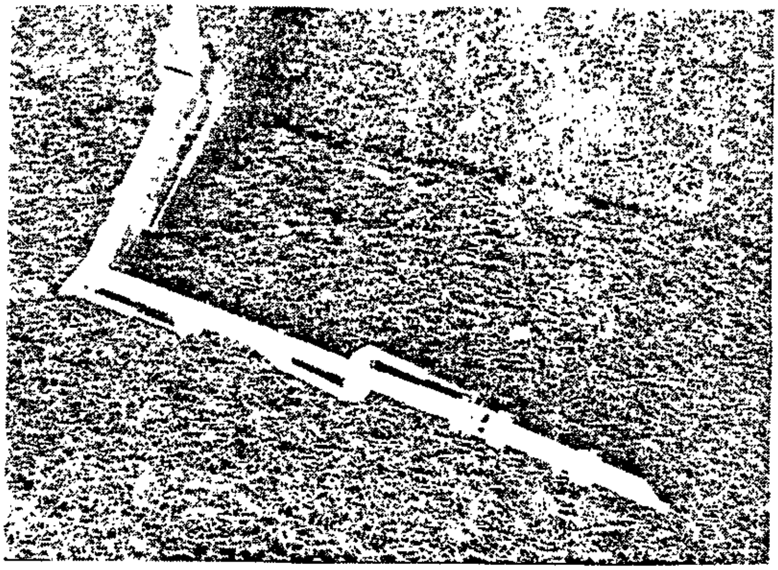
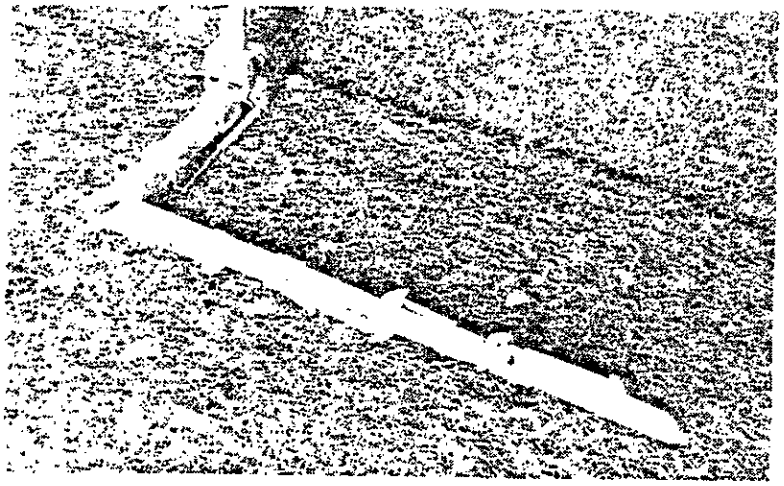


Figure 7-15

Figure 7-16



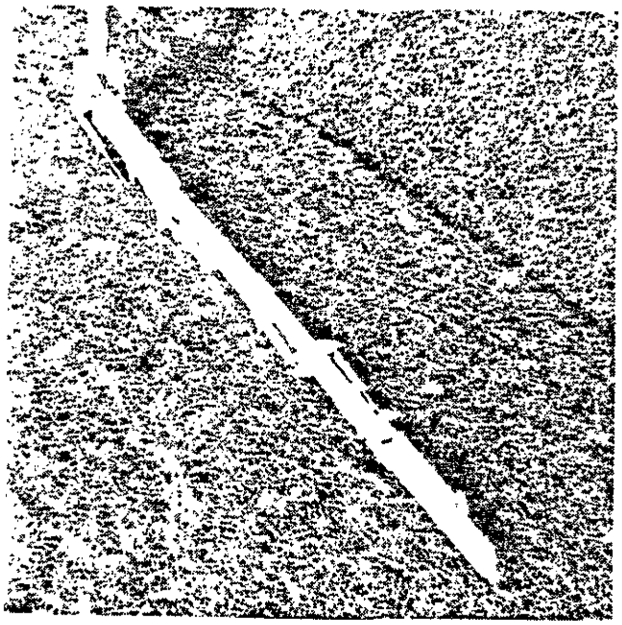


Figure 7-17

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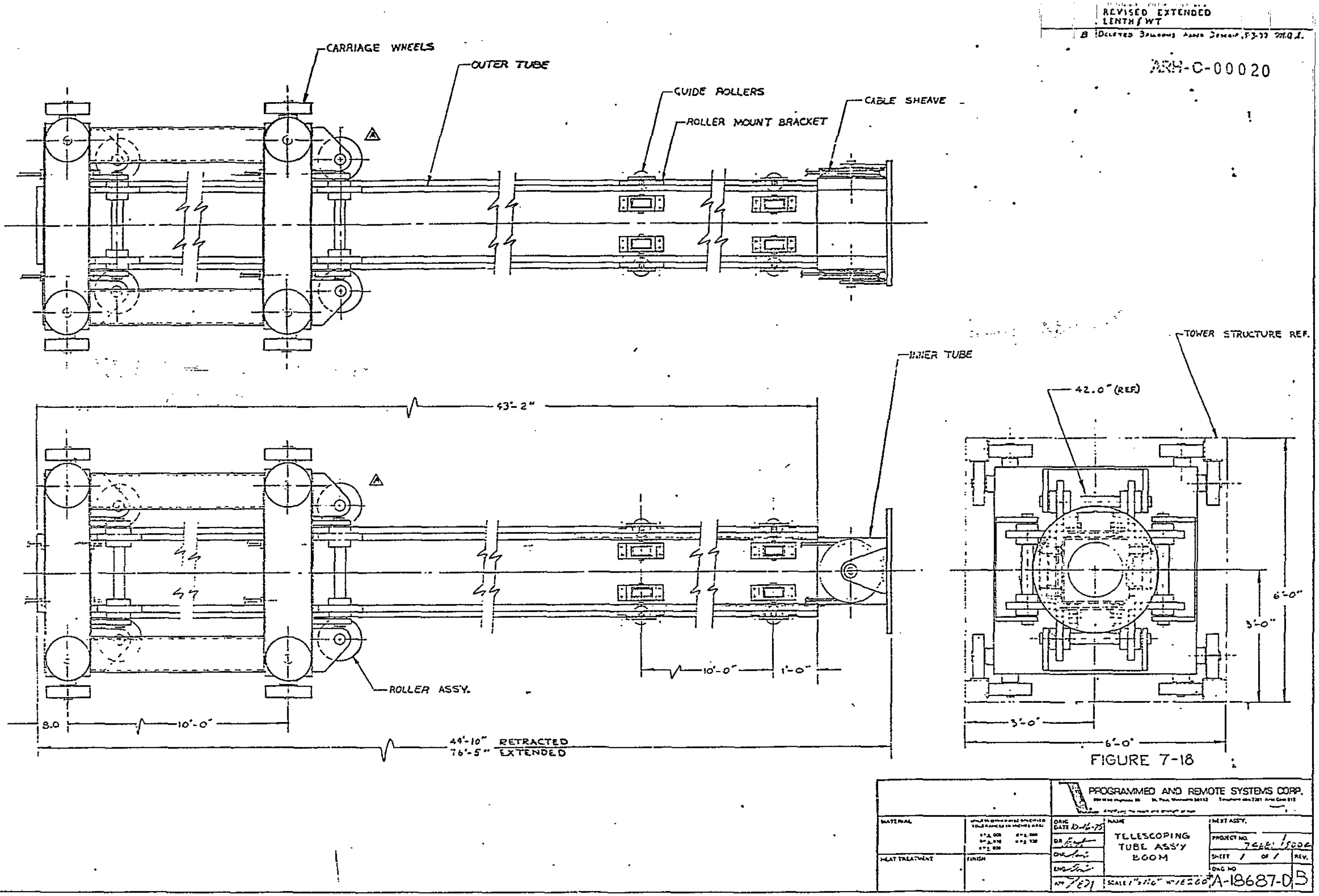

FIGURE 7-18

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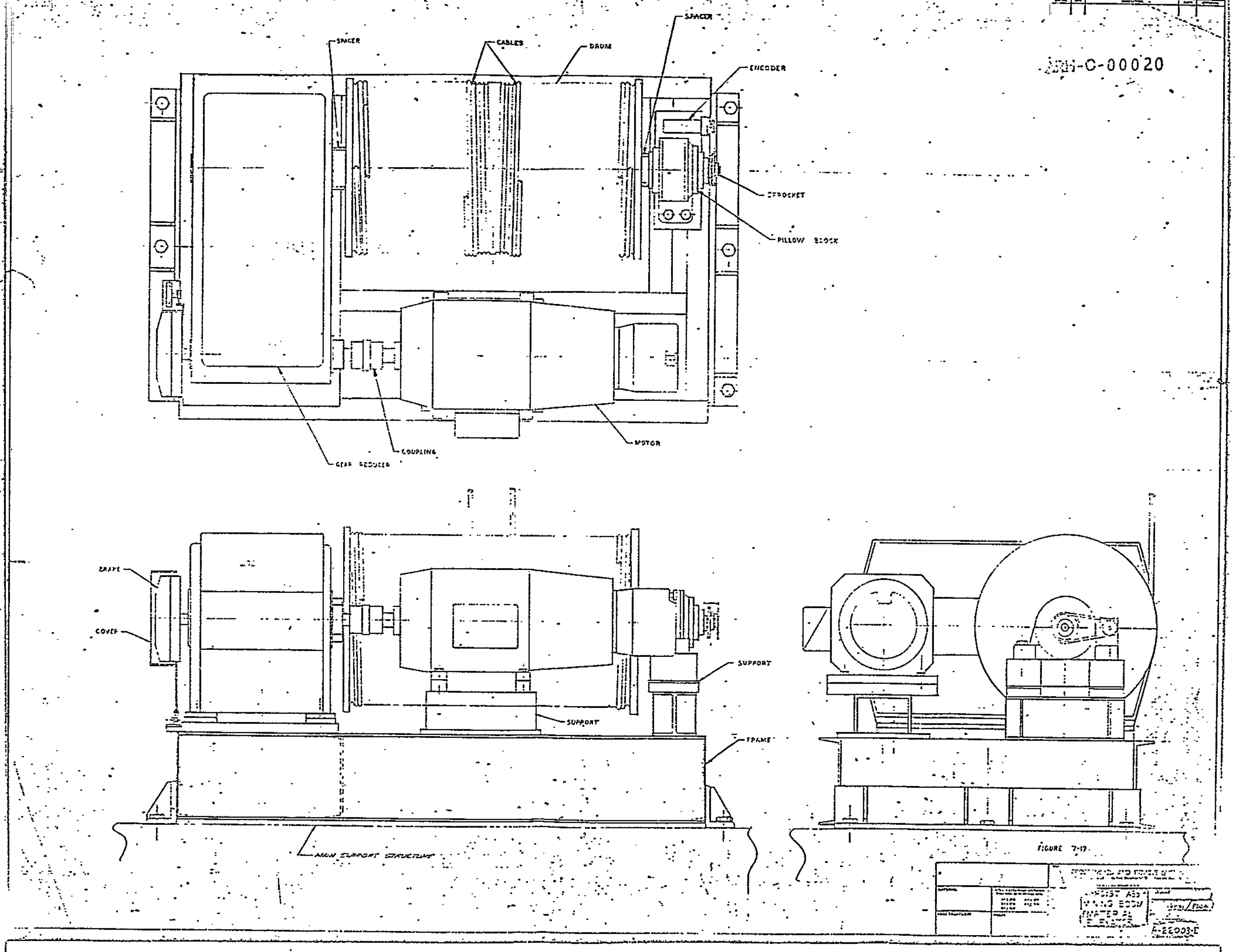

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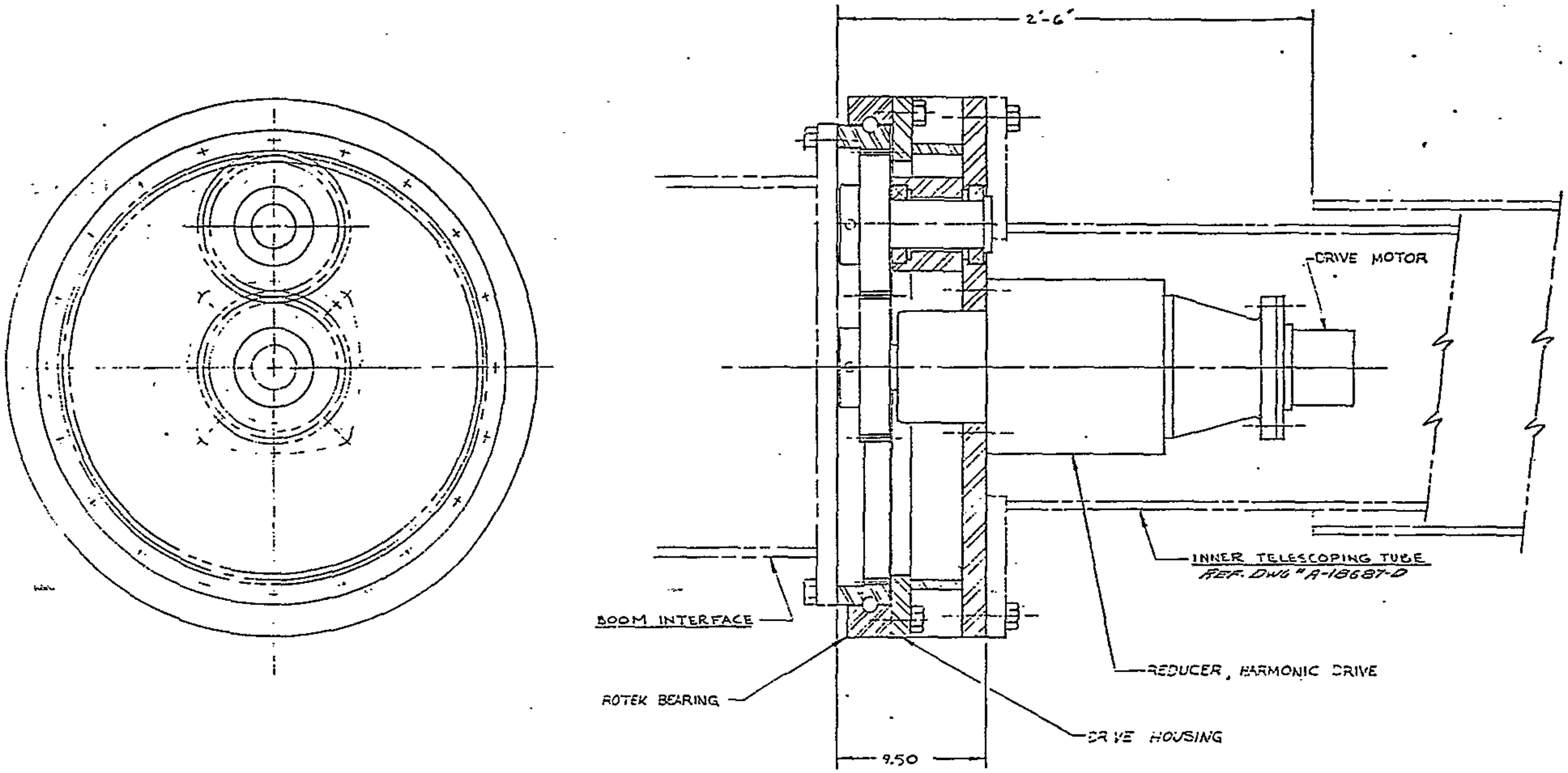

FIGURE 7-20

PROGRAMMED AND REMOTE SYSTEMS CORP.	
MATERIAL	HEAT TREATMENT
FINISH	
ORIG DATE 9-25-75	NAME: MINING BOOM ROTATE DRIVE
NEXT ASSY	PROJECT NO 7460 / 5000
SHEET 1 OF 1	REV
SCALE 1/2	DWG NO A-18603-D

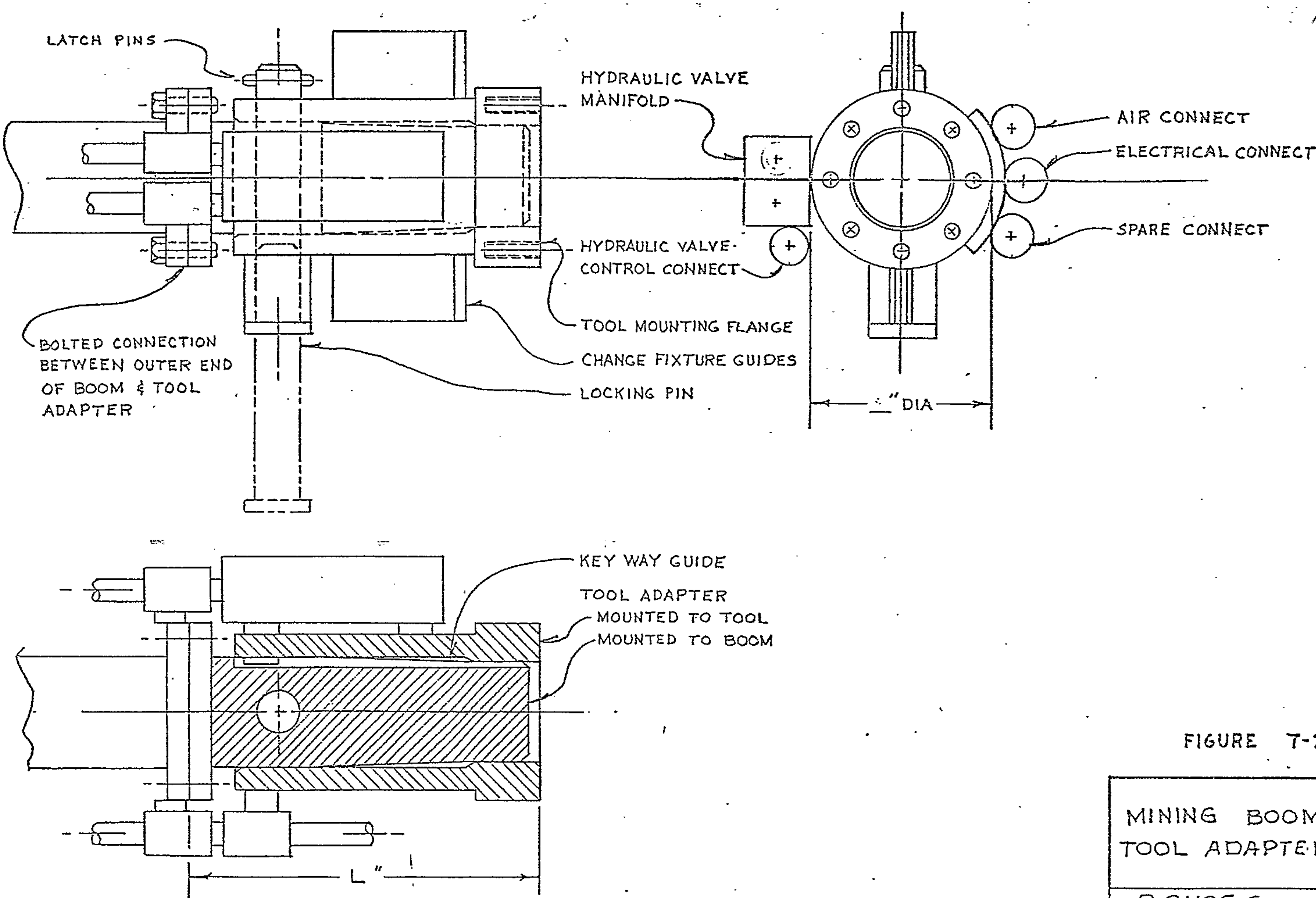

FIGURE 7-21

MINING BOOM TOOL ADAPTER

P-21195-C

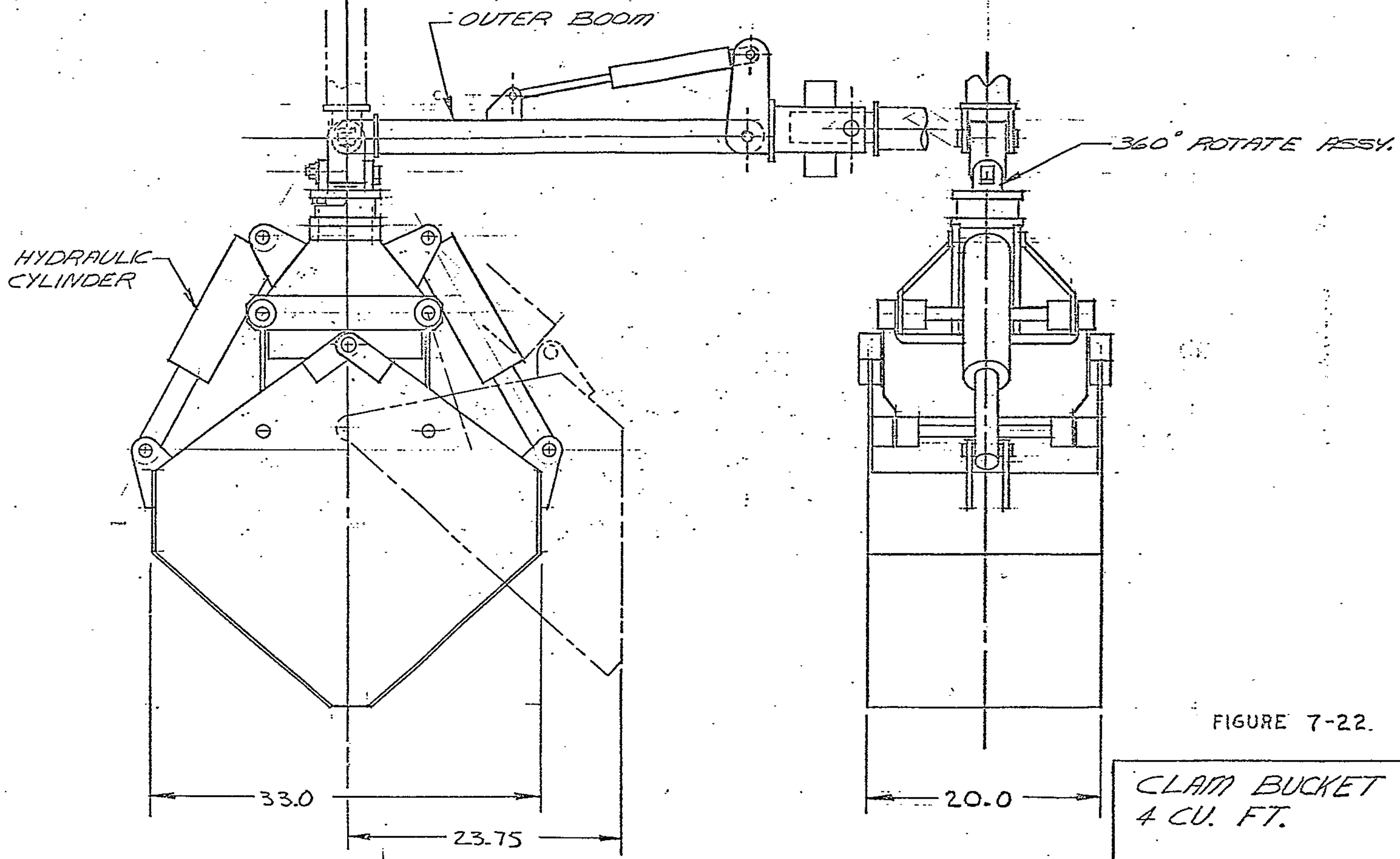

FIGURE 7-22.

CLAM BUCKET
4 CU. FT.

P-21199-C

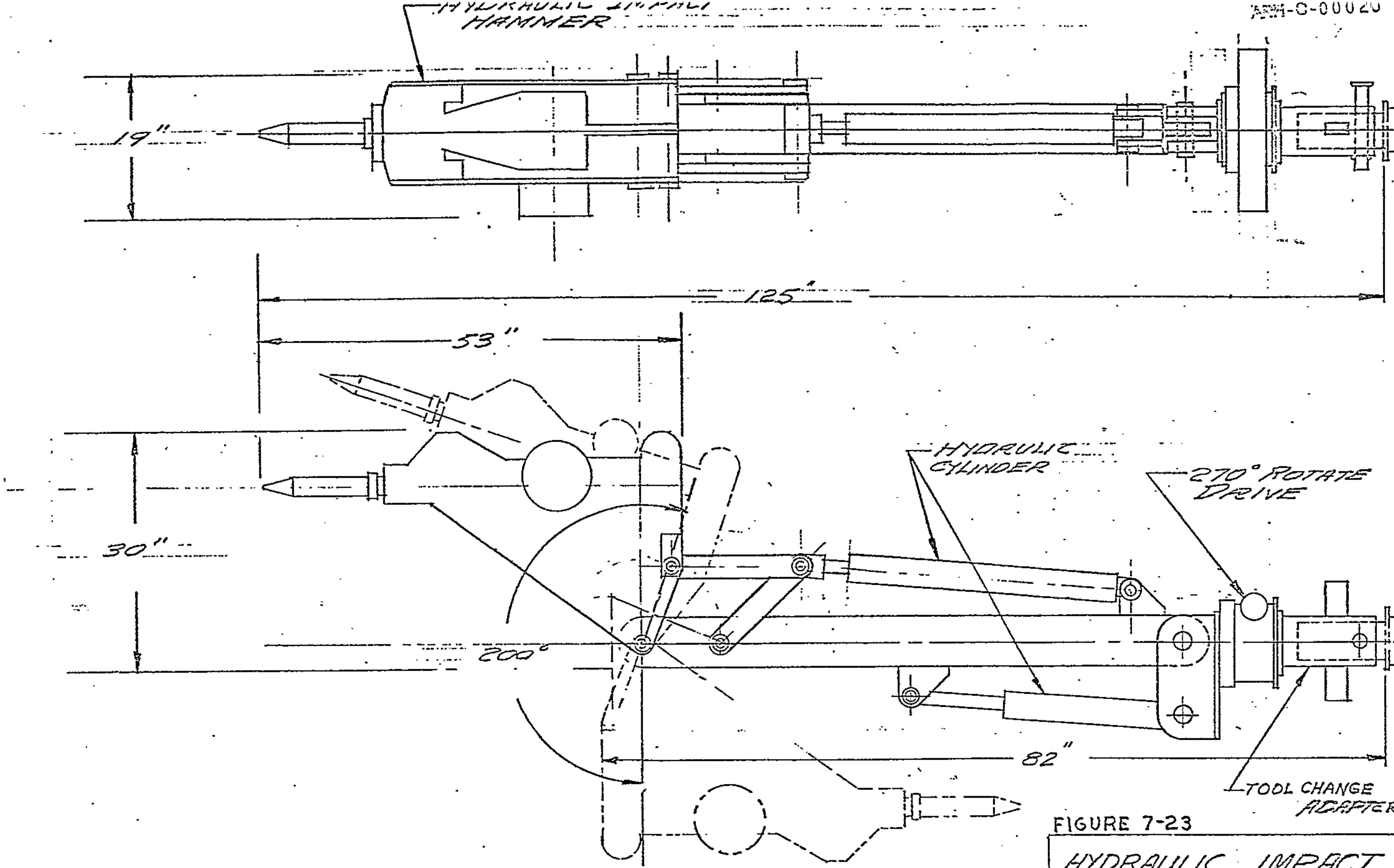

FIGURE 7-23

HYDRAULIC IMPACT HAMMER

P-21202-C

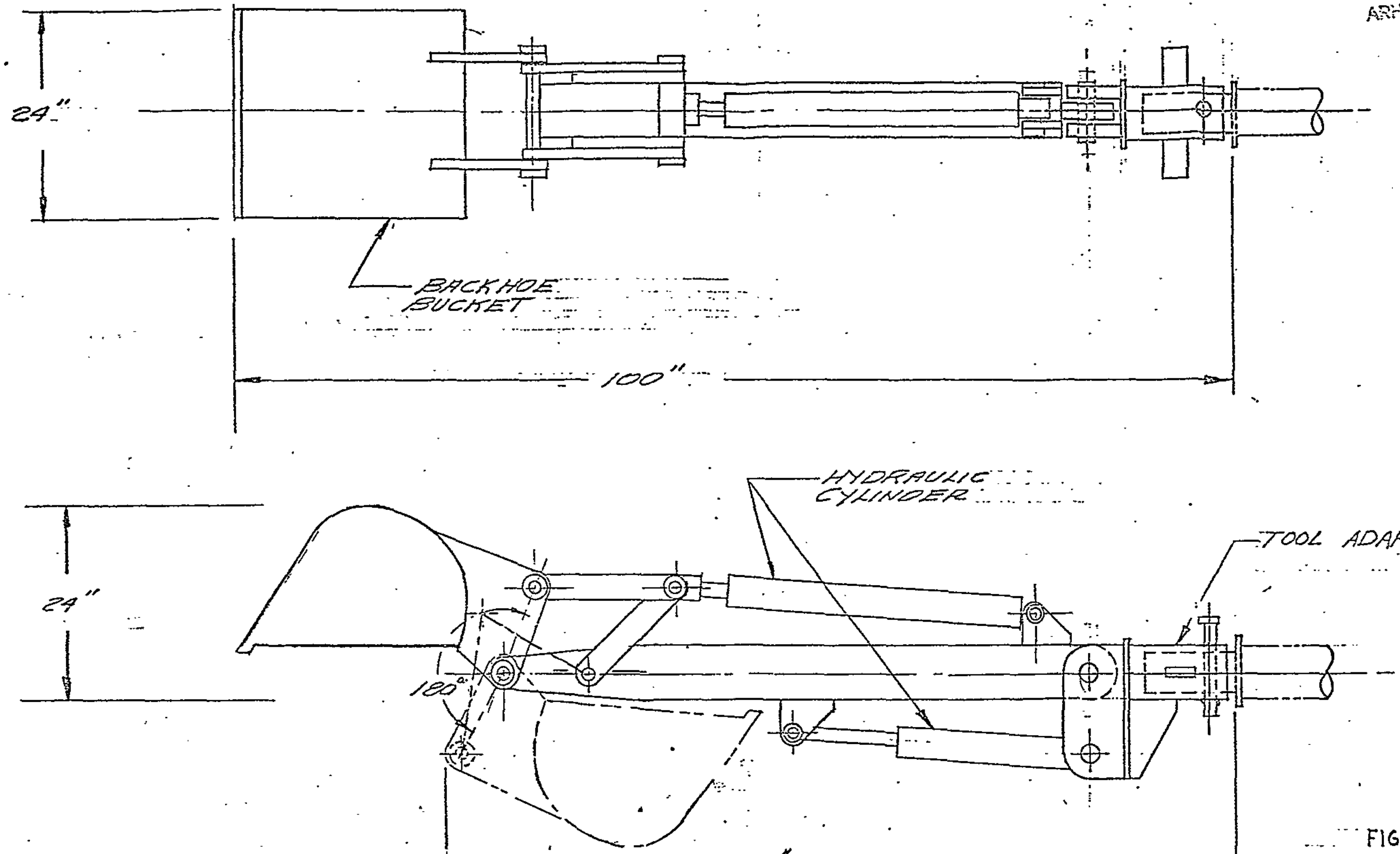

FIGURE 7-24

BACK HOE
4 CU. FT.

P-21198-C

ACM-0-00020

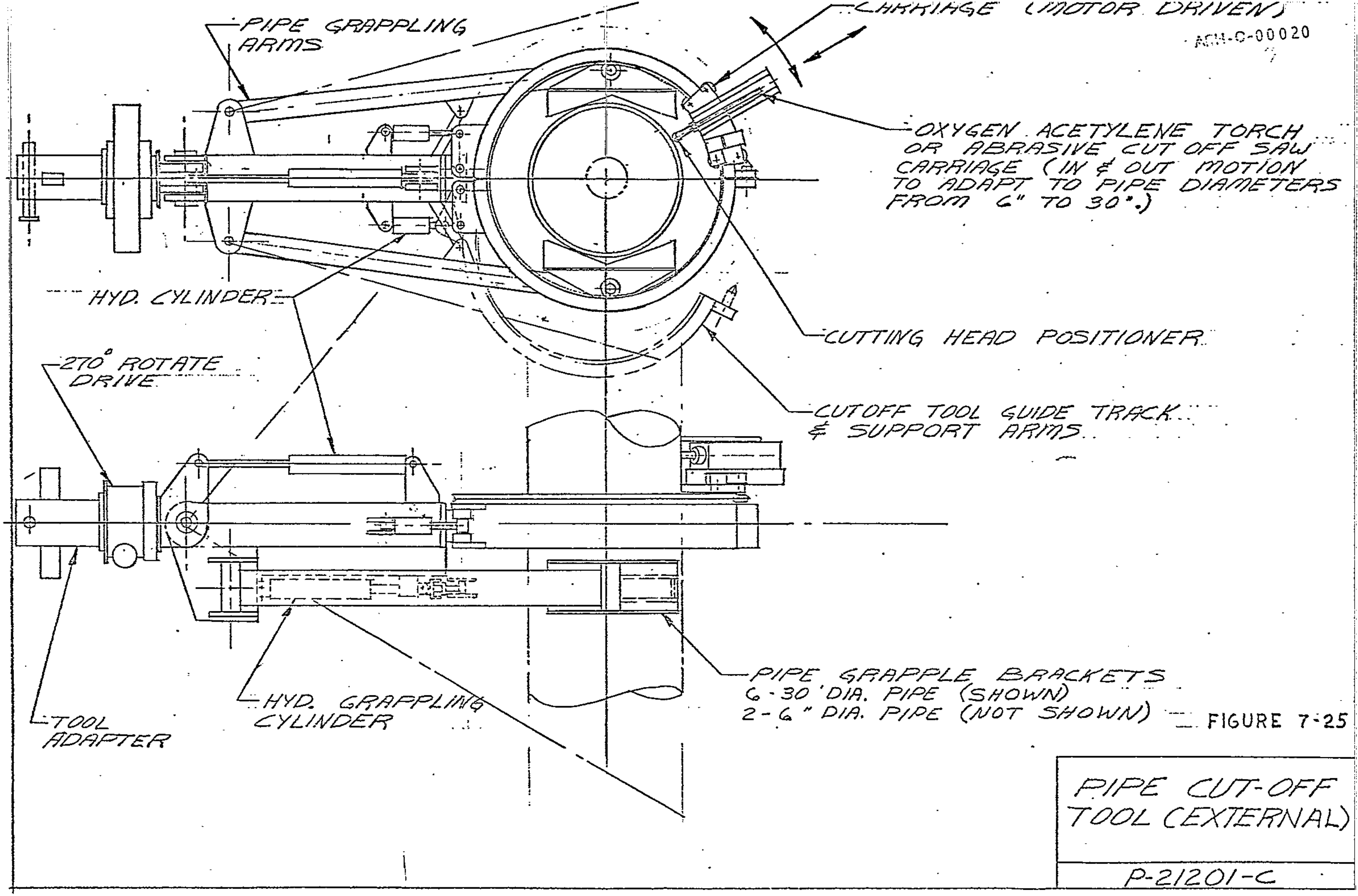

FIGURE 7-25

PIPE CUT-OFF TOOL (EXTERNAL)

P-21201-C

9212501074

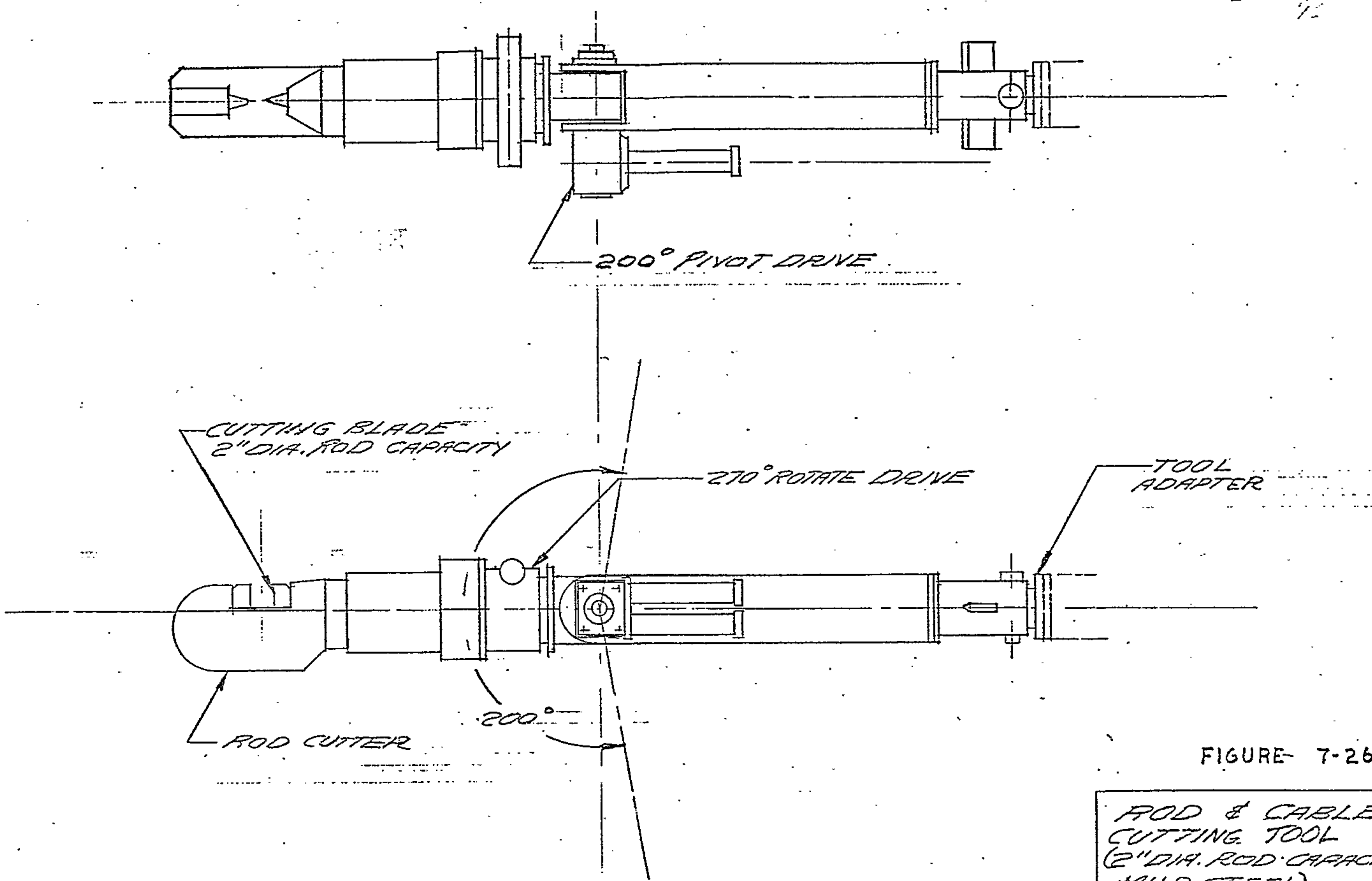

FIGURE 7-26

ROD & CABLE CUTTING TOOL (2" DIA. ROD CAPACITY, MILD STEEL)
100 TON THRUST
P-21196-C

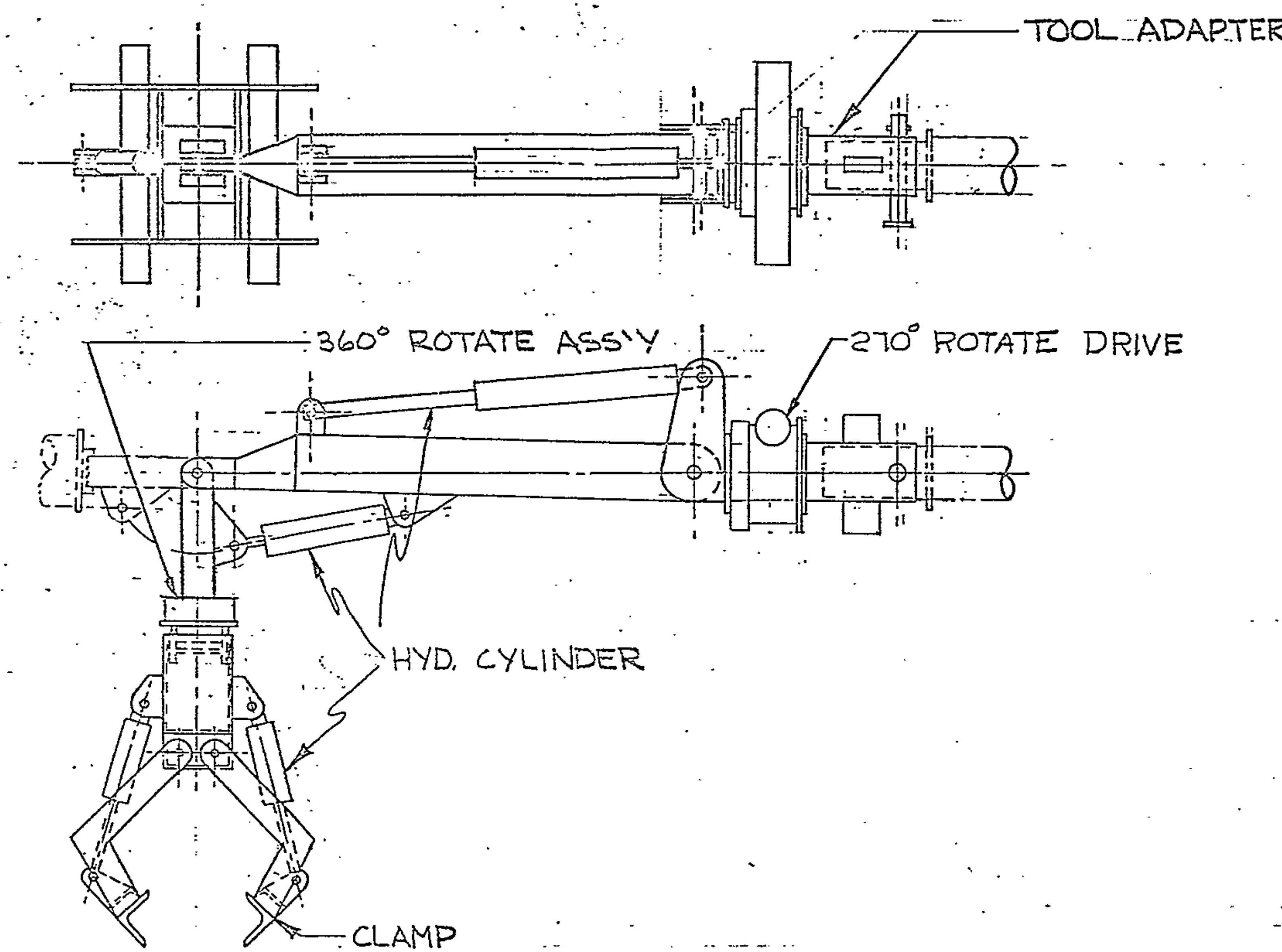

FIGURE 7-27

OBJECT HANDLING TOOL

P-21197-C

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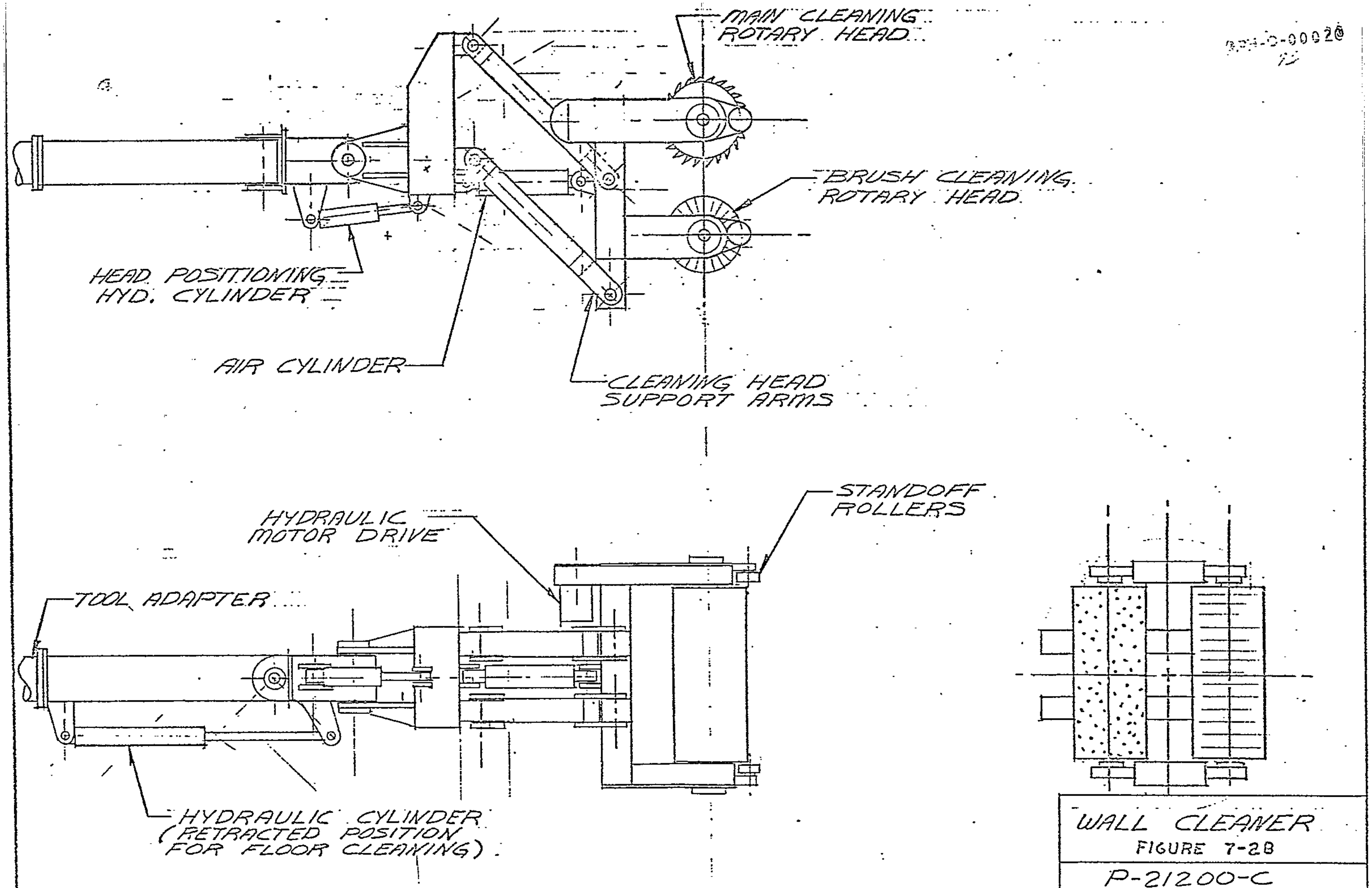

WALL CLEANER

FIGURE 7-2B

P-21200-C

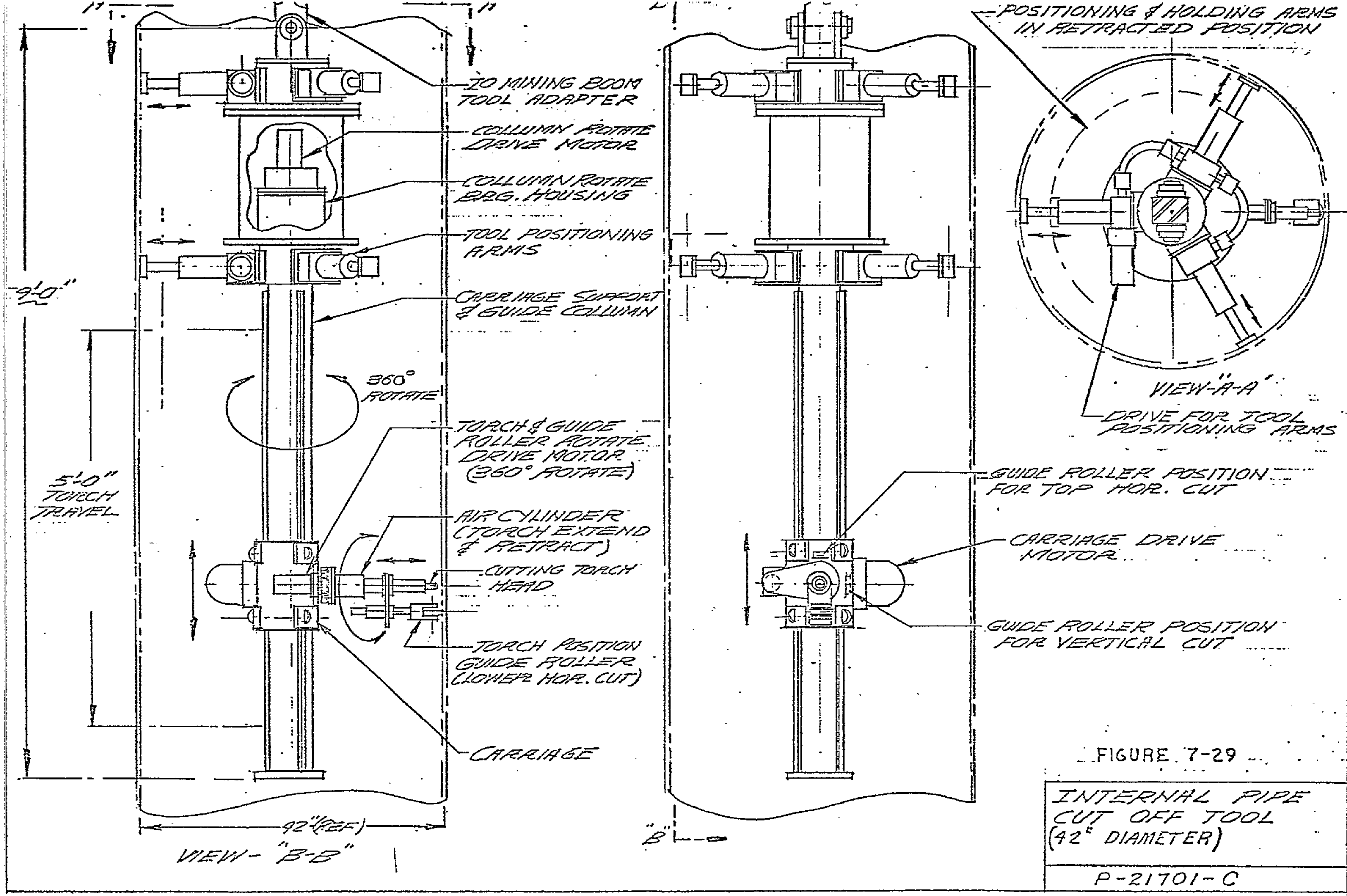

FIGURE 7-29

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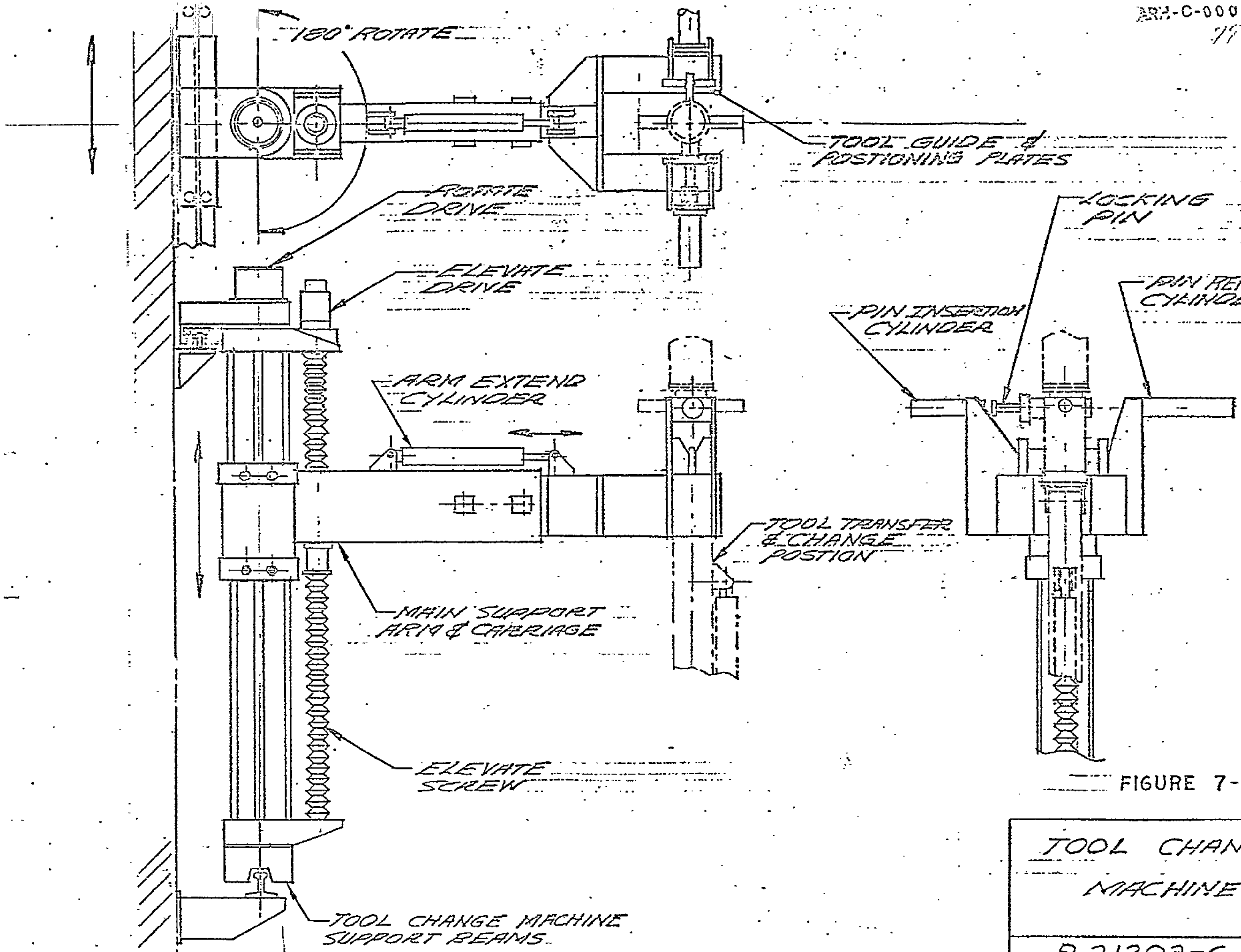

FIGURE 7-30

TOOL CHANGE MACHINE

P-21203-C

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9 2 1 2 5 0 1 0 1 3 0

7.1.1 SPECIFICATIONS

1.	Rated load capacity	3000 lbs. max.
2.	Operating hydraulic pressure	2000 psi
3.	Approximate weights	
	a. boom	7,075 lbs.
	b. telescoping tubes, carriage and boom rotate with hydraulics	18,695 lbs.
	c. clam bucket tool	850 lbs.
	Total	26,620 lbs.

4. Motion Specifications

Motion	Type of Actuator	Travel	Speed
Telescoping tube hoist	Electric driven hoist	97 ft.	25 ft./min.
Main boom rotate	Hydraulic motor, gear reducer	360 degrees	1/2 RPM
Inner boom down pivot	Hydraulic cylinder	100 degrees	1/3 RPM
Inner inter-mediate side pivot	Hydraulic cylinder	100 degrees	1/2 RPM
Outer inter-mediate side pivot	Hydraulic cylinder	100 degrees	3/4 RPM
Outer boom side pivot	Hydraulic cylinder	100 degrees	1 RPM

Tool motion specifications vary depending upon the tool. See Section 7.2.

The speeds given are maximums. The telescoping tube hoist is fixed speed. The other motions are controllable continuously over a ten to one speed range.

7.1.2 MINING BOOM TELESCOPING TUBE ASSEMBLY (Ref: Figure 7-18)

The telescoping tubes have two moving sections, one of which is mounted in a carriage which travels up and down the boom support tower. This outer tube moves in the carriage guided by rollers. The second tube travels up and down inside of the outer tube guided by guide rollers. Dual hoist cables attached near the bottom of the inner tube, pass over sheaves mounted to the top of the tower and down to an electrically driven winch on the roof of the structure. The telescoping tubes provide enough vertical travel to allow the mining boom to be completely withdrawn from the tank and to provide full coverage of the tank interior. When the boom is completely withdrawn, the carriage is at the top of the tower and the tube protrudes upward through a sealed door in the top of the tower.

When the outer tube has been lowered to the maximum travel position, a clamping device mounted at the floor is actuated. This clamp ties the tube to the main structure at the floor level to provide additional lateral support.

7.1.3 HOIST ASSEMBLY(MINING BOOM AND MATERIAL ELEVATOR) (Ref: Figure 7-19)

Hoist assemblies used for both the mining boom and the material elevator are of the same design. The hoist assemblies are used for raising and lowering the mining boom and the material elevator in and out of the tank. They are mounted on the roof at the base of the towers.

The major components consist of the drive motor, gear reducer, drum and the cables.

An encoder is driven by a sprocket on the drum shaft to indicate position readout. An electric brake holds the load when the hoist is not energized.

7.1.4 MINING BOOM ROTATE DRIVE (Ref: Figure 7-20)

The mining boom is mounted to the inner telescoping tube through the hydraulically powered rotate assembly. The rotate drive consists of a hydraulic motor, gear reducer, drive gears, and a bearing. The rotate drive provides for 360 degrees of rotation for the mining boom.

7.1.5 MINING BOOM WASHDOWN

The mining boom tower serves as a chamber in which the boom is washed after being withdrawn from the waste tank. Washing of the boom is performed after the tool has been removed. When the boom is at the uppermost position, and there is no tool on the end, a door at the base of the tower can be closed. In this manner the wash water is collected and returned to the wash water receiving tank.

There are a number of spray nozzles located at appropriate spots within the tower which direct warm water at the boom. When washing is completed, the door at the base of the tower is opened and hot air is blown over the boom to dry it.

7.2 MINING BOOM TOOLS

The mining boom is capable of reaching all locations within a waste storage tank below the maximum material level. It is equipped with a variety of tools capable of removing waste material ranging in characteristics from slurries to hard salt cake and metallic debris.

The outer end of the boom has a remotely operable connection to allow the tools to be interchanged remotely.

Tool changing is accomplished with a special tool change machine located in the mining boom room of the waste retriever.

A basic selection of tools and means for interchanging them have been designed conceptually. Other tools as may be required can be accommodated.

The basic functions to be accomplished with boom mounted tools include:

- breaking up hard salt cake material
- cutting off pipes and other in-tank obstacles
- final clean-up of tank walls and bottom
- picking up and moving materials to the elevator
- carrying a slurry pump or other special equipment

The tools required for the above functions include:

- clam bucket
- impact hammer
- back-hoe
- pipe cut-off tool (external)
- shearing tool- rod and cable cutter
- object handling tool

- wall cleaner

A description of the tools and tool change equipment follows:

9 2 1 2 5 9 1 0 1 3 4

7.2.1 MINING BOOM TOOL ADAPTER (Ref: Figure 7-21)

The tool adpater is shown in Figure 7-21. One part of the adapter bolts to the outer end of the boom. This allows it to be replaced periodically if required. The other half of the adapter is bolted to the tool at the tool mounting flange.

A locking pin which latches in the locked position is used to connect the tool the boom.

The hydraulic valve manifold which controls the hydraulic functions of the tool is mounted on the tool portion of the adapter. Remote connects are provided for two hydraulic lines, hydraulic valve control, air, electrical power and an additional utility. These automatically connect or disconnect along with the tool adapter.

Guides on the outer portion of the tool adapter are used for supporting the tool in a tool change fixture.

A tool is connected to the boom by inserting the boom portion of the adapter into the tool mounted socket portion. A key and keyway keep the mating halves in the proper angular position. After the two portions have been engaged and upon further motion, the utilities connections are made. After full-travel engagement, the locking pin is moved to the lock position by means of a hydraulic cylinder on the tool change machine. Spring-loaded latch pins on the locking pin assure that it cannot disengage inadvertently.

Tool disconnect is done in the reverse order. The hydraulic cylinder which disengages the locking pin has a spring loaded fitting which depresses the latch pins prior to pushing on the locking pin.

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7.2.2 CLAM BUCKET (Ref: Figure 7-22)

The clam bucket is a rather conventional material handling device which is expected to be a much-used tool for removing waste material and transporting it to the material elevator. At the point of attachment to the mining boom there is a universal joint which allows the bucket to hang vertically and to adjust its position as the bucket halves dig into the material being removed.

Immediately below this joint there is a rotate bearing and rotate drive so that the bucket assembly can be rotated to the desired orientation before being dropped into the waste material. The two halves of the bucket are actuated by hydraulic cylinders which work in unison to open or close the clam shells. When fully opened the bucket can remove material which is close to the tank wall.

To facilitate maneuvering of the clam bucket, the end section on which it is mounted has a pivot and actuating cylinder to allow the end section to pivot downward.

Specifications for the clam bucket are as follows:

Capacity		4 cu. ft.
Weight		850 lbs.
Dimensions of clamshell		
	Closed	20x33x50 Inches
	Open	20x47.5x47.5 Inches

Rotate Angle	360 degrees
Rotate Rate (max.)	10 RPM
Required oil flow rate	15 GPM
Material	Carbon Steel
Pivot Angle	90 degrees
Pivot Rate (max.)	2 RPM

7.2.3 HYDRAULIC IMPACT HAMMER (Ref: Figure 7-23)

It is anticipated that in some tanks it will be necessary to break up hard layers of salt cake and to remove hard deposits of salt cake which have built up on tank walls or in-tank obstacles. The hydraulic impact hammer shown in Figure 7-23, is the tool provided for this purpose.

The impact hammer is a commercial unit which is mounted on a structure which allows the impact tool to be oriented as necessary by means of tilt and rotate drives. The stub section on the end of the mining boom, which mates with the tool change adapter, pivots to provide a panning motion.

Specifications for the impact hammer are as follows:

Impact energy per blow	200 ft. lbs.
Blows per minute	1250
Weight, impact hammer only	700 lbs.
Weight, complete assembly	1460 lbs.
Hammer tilt angle	20 degrees up 180 degrees down
Hammer tilt rate (max.)	3 RPM
Tool assembly tilt angle	90 degrees
Tool assembly tilt rate (max.)	2 RPM
Tool assembly rotate angle	270 degrees
Tool assembly rotate rate (max.)	4 RPM
Required oil flow rate	15 GPM
Overall dimensions	125"x19"x30"
Material	carbon steel

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7.2.4 BACK HOE (Ref: Figure 7-24)

This is a conventional hydraulically operated back hoe bucket mounted on a spar. There is a hydraulic rotate drive on the spar, and a hydraulically actuated tilt motion.

The back hoe will be used primarily for breaking up medium hard salt cake and for moving material into piles suitable for pick up by other tools. If a considerable amount of material remains on the tank walls after use of the clam bucket, the back hoe can be used for removing this material prior to using the final clean up tool.

Back hoe specifications are as follows:

Capacity	4 cu. ft.
Weight	725 lb.
Overall dimensions, extended	100"x24"x24"
Bucket tilt angle	180 degrees
Bucket tilt rate (max.)	10 RPM
Spar tilt angle	45 degrees down
Spar tilt rate (max.)	4 RPM
Required oil flow rate	15 GPM
Material	carbon steel

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7.2.5 <u>PIPE CUTOFF TOOL - EXTERNAL</u> (Ref: Figure 7-25)

The pipe cutoff tool is a device for use in cutting off pipe and transporting the pieces to the material elevator. It is designed for cutting pipe ranging in diameter from approximately two inches to 30 inches.

The tool has two sets of hydraulically actuated arms which encircle the pipe. One set of arms has jaws which clamp down on the pipe; the other supports the actual cutting tool and provides a track on which the tool carriage is driven around the perimeter of the pipe. A follower on the tool carriage maintains the proper spacing between the tool and the pipe.

In operating the cutoff tool, the clamps would be positioned on the section of pipe that is to be removed. Thus, when the cutting has been completed, this freed section will remain clamped in the device and can be carried over to the material elevator before being released. Proper orientation of the assembly relative to the pipe is accomplished by means of a pivot joint and a rotate drive. The pivot joint is on the frame of the tool and the rotate drive is incorporated in the end of the assembly which attaches to the mining boom. For a vertical pipe supported from above, the clamps would be located below the cutting tool. For a pipe supported from below, the clamp would be positioned above the cut off plane.

The carriage support collar has alignment pins to insure proper mating of the carriage tracks. The carriage drive system is built into the carriage.

The cutting tool proper could be a torch, an abrasive cutting saw, a band saw, or an arc-saw. The torch would be the fastest means available to perform the cutting action. It would require a gas supply and igniter.

Specifications for the pipe cutoff tool are as follows:

- Pipe diameter capability *	2 to 6 inches 6 to 30 inches
- Weight	1000 lbs.
- Dimensions overall (closed)	9' long x 38" wide
- Pivot Angle	± 45 degrees
- Pivot Rate (max.)	2 RPM
- Rotate Angle	270 degrees
- Rotate Rate (max.)	2 RPM
- Required oil flow rate	10 GPM
- Material	Carbon steel and stainless steel

* Two sets of pipe jaws are provided; one for diameters from 2 to 6 inches and the other for 6 to 30 inches.

7.2.6 ROD AND CABLE CUTTING TOOL (Ref: Figure 7-26)

The hydraulic shearing tool is used to cut off and chop up small pipe, tie rods, hose, cable, and such obstacles. The shear is commercially available and is mounted on a structure which provides tilting and rotating motion. Panning motion is obtained from the outermost boom pivot joint.

Specifications for the shearing tool are as follows:

- Capacity	Up to 2" dia. steel bar
- Thrust	85 tons
- Cutting Cycle	4 seconds
- Weight (cutter only)	240 lbs.
- Weight (overall)	900 lbs.
- Pivot Angle	200 degrees
- Pivot Rate (max.)	2 RPM
- Rotate Angle	270 degrees
- Rotate Rate (max.)	2 RPM

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7.2.7 <u>OBJECT HANDLING TOOL</u> (Ref: Figure 7-27)

The object handling tool is used to pick up miscellaneous objects in the tank and move them to the material elevator.

The motions and mounting of the object handling tool are similar to those of the clam shell bucket.

Specifications for the object handling tool are:

- Load Capacity	2000 lbs.
- Weight	850 lbs.
- Clamp Travel	
Closed	4"
Open	32"
- Clamp Rotate Angle	360 degrees
- Clamp Rotate Rate (max.)	10 RPM
- Pivot Angle	90 degrees
- Pivot Rate (max.)	2 RPM
- Boom Rotate Angle	270 degrees
- Boom Rotate Rate (max.)	2 RPM
- Material	carbon steel

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7.2.8 WALL CLEANER (Ref: Figure 7-28)

The wall cleaner uses two hydraulically driven heads to remove the final material from the walls and bottom of the tank.

The rotary heads are kept against the tank surfaces by an air-cylinder actuated four-bar linkage. Stand-off rollers prevent the heads from cutting into the tank.

Hydraulically actuated pivots allow the rotary heads to be positioned to cover all tank surfaces.

One of the heads will be a brush. The use of small quantities of water from a recycling tank incorporated into the tool may assist in obtaining the desired tank cleanliness.

Specifications for the wall cleaner are:

- Weight	1150 lbs.
- Down Pivot Angle	90 degrees
- Head Positioning Angle	45 degrees
- Pivot Rate	2 RPM
- Air Cylinder Extend	8 inches
- Width of Cleaning Path	24 inches approx.
- Material	carbon steel

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7.2.9 PIPE CUTOFF TOOL - INTERNAL (Ref: Figure 7-29)

The internal pipe cutoff tool is a device used for cutting the central 42-inch diameter riser pipes into segments from the inside. It is used for those tanks with central risers extending down far enough into the tanks to prevent the installation of the mining boom unless the riser is cut away.

Proper orientation of the cutoff tool inside the pipe is accomplished with positioning and holding arms. When extended, the arms center and hold the cutting tool in place when doing the cutting operation.

A main support column provides 360 degrees of rotation for the cutting torch to make the horizontal cuts around the inside perimeter of the pipe. The support column also guides the carriage when making the vertical cuts dividing the pipe section into segments.

The carriage incorporates a carriage drive for driving the carriage up and down the support column, a torch and guide roller rotate drive for proper orientation of the torch guide roller, an air cylinder for extending and retracting the cutting torch head and a torch guide roller for maintaining the proper spacing between the cutting torch and pipe.

Once the cutting tool is in position, the pipe is cut into segments by first making the vertical cuts. This is accomplished by energizing the carriage drive motor and running the carriage up and down the support column. At the end of each vertical cut, the support column is rotated at 45 degrees intervals until eight cuts have been made. Once the vertical cuts have been completed, the lower and upper horizontal cuts can be made to free the eight pipe sections.

The lower cut is made first by running the carriage down to its lower end travel position on the support column. The torch and guide roller are then extended and oriented properly for making the perimeter cut. The support column is then rotated 360 degrees with the torch intersecting all the lower ends of the vertical cuts.

The carriage is then run up to its upper end travel on the support column. The torch and guide roller are then reoriented with the guide roller directly above the cutting torch and extended up against the pipe wall. The support column is rotated 360 degrees and as the torch passes through the vertical cuts, the segments drop out and away until the entire pipe section has been removed.

If required, the cutting tool can be re-positioned inside the pipe for the next section to be cut out. The desired length of pipe can be removed in this way.

Specification for the internal pipe cutoff tool are as follows:

- Pipe diameter capability	42 inches
- Weight	800 lbs.
- Overall length	9 ft.
- Support column rotate	360 degrees
- Carriage travel (max.)	4'-6"
- Torch and guide roller rotate	360 degrees (2 RPM)
- Torch extend and retract	4 inches
- Material	carbon and stainless steel

7.2.10 <u>OTHER TOOLS</u>

Other tools, such as a slurry pump and a double wall pipe cutoff tool can be mounted on a tool adapter and used with the mining boom.

A development program including test work with prototype tools and simulated in-tank material may indicate the advisability of additional tools or modifications to the ones described above. It is believed that the mining boom and tool adapter concepts will accommodate such changes.

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7.3 TOOL STORAGE RACKS & CHANGE MACHINE
(Ref: Figure 7-30)

The various tools are stored in racks located in the mining boom room of the waste retriever. They are supported in the racks by change fixture guides bolted onto the tool adapters.

Two racks are located so that they can be reached by the tool change machine. One of these racks holds the next tool to be used. The other is empty so that it can take the tool being removed from the mining boom. An overhead crane which spans the tool storage area and travels its length, moves the tools from rack to rack. The crane hook can be rotated for proper orientation of the tool being placed into a rack.

The tool change machine shown in Figure 7-30 is mounted in the mining boom room. The main elements of the machine are: support beams; horizontal drive; a 180-degree rotate drive; an elevate drive; an extendable support arm; tool guide and positioning plates; and pin insertion and removal cylinders.

In a typical tool change operation:

- The mining boom is raised to its tool change position
- The tool change machine,with its arm retracted, is moved and rotated to be in line with the mining boom.
- The change machine arm is extended to place its guide plates under guides on the boom mounted tool
- The change machine is elevated to support the tool
- The pin removal cylinder is actuated to retract the latch pins on the tool adapter and move the locking pin to the unlocked position.
- The change machine is lowered to disconnect the tool adapter, rotated from underneath the mining boom and moved to the tool washing station, where it places the tool on a stand and is then retracted. This stand is part of the tool maintenance cart.

- The change machine is moved and rotated into alignment with the rack holding the next required tool and then extended to pick up the tool from its storage rack.

- The change machine is rotated under the mining boom, elevated and actuated to connect the tool and then withdrawn.

- After adequate washing the first tool is either picked-up by the change machine and placed in a storage rack ready for re-use, or moved, via the tool maintenance cart, to the maintenance room if required.

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7.4 TWO-TON CRANE

The two-ton crane in the boom room is used to move mining boom tools between storage racks and for special handling functions.

The crane bridge runs on rails connected to the waste retriever structure. The rails are at an elevation which allows the crane to pass beneath both the mining boom and the material elevator when they are in their fully retracted positions. This enables the two-ton crane to operate in the filling room and maintenance room in addition to the mining boom room, its normal operating area. The hoist is mounted on a trolley which runs on the bridge to provide coverage of the entire areas.

A four part rope is used to prevent undue rotation of the lifting fixture and items carried by it.

7.5 TOOL WASH STATION

The tool wash station is a chamber with a floor size of approximately 7 feet by 7 feet and a wall height of 12 feet 6 inches. Access doors open to permit entry from both the mining boom room and the maintenance room. The roof panel hinges upward so that, with both access doors open, the wash station becomes a passageway through which the 2-ton crane or the Model 3000 manipulator can carry items from room to room. The walls, doors and roof panel are shielded with 1/8 inches of lead.

The tool wash station contains washing, drying and radiation monitoring equipment. Spray nozzles are appropriately oriented to direct wash water at the central space where items are held while being washed. Separate hot-air nozzles are similarily positioned for drying the washed items.

Mining boom tools, mining boom components or other items to be washed are supported on the tool maintenance cart. If the Model 3000 manipulator becomes contaminated it can be washed by extending it down into the chamber.

Rails for the tool maintenance cart are located in the floor of the wash station and extend into the maintenance room.

8.0 SHIPPING AND RECEIVING ROOM AND FILLING ROOM EQUIPMENT (Ref: Figures 2-1 & 2-2)

These rooms contain equipment which receives material removed from the tank, packages it suitably for shipment, loads transport trailers for shipment to a processing plant and receives empty containers for re-use. The rooms must provide adequate shielding and atmospheric containment for the radioactive materials being handled.

General considerations used in the design of the shipping and receiving room and the filling room are:

- A production line operation is used to perform the highly repetitive packaging operation which is the primary purpose of the rooms.

- The equipment within the rooms is to be as simple and reliable as possible. Provisions for maintaining the equipment with a minimum amount of down-time are included.

- The working volume which requires shielding is a minimum to reduce the weight of shielding required.

The main components of the shipping and receiving and filling rooms are:

- an unshielded shipping and receiving area

- a shielded, controlled-air, filling room in which open radioactive material is handled.

- two combination shielding and air-locks

- a turntable for moving shipcons through the loading cycle

- a shipcon lid handling mechanism

- a shipcon washing device built into one of the air locks

- a turntable washing device built into the same air lock

- a 20-ton overhead crane which services the shipping and receiving area

- a central shielded door used for moving large objects into and out of the shielded area

- a door system which allows the 20-ton crane to move out of the shipping and receiving room and over the transport trailer.

The unshielded room is used to unload a set of empty containers from the trailer, remove the shipcon from the sealcon and place the shipcon on the turntable ready for movement into the filling room. It also receives capped, filled and washed shipcons from the filling room, places them in sealcons and loads them onto the trailer for transport to the processing plant.

The filling room is approximately 20 feet long, 22 feet wide and 20 feet high. The 1 1/2" thick lead shielding extends from the floor of the room to an elevation of 17 feet. Additional shielding at the base of the elevator tower continues up 7 feet more.

The top and floor of the filling room are not shielded. The elevation of the shielding precludes exposure of personnel on the ground.

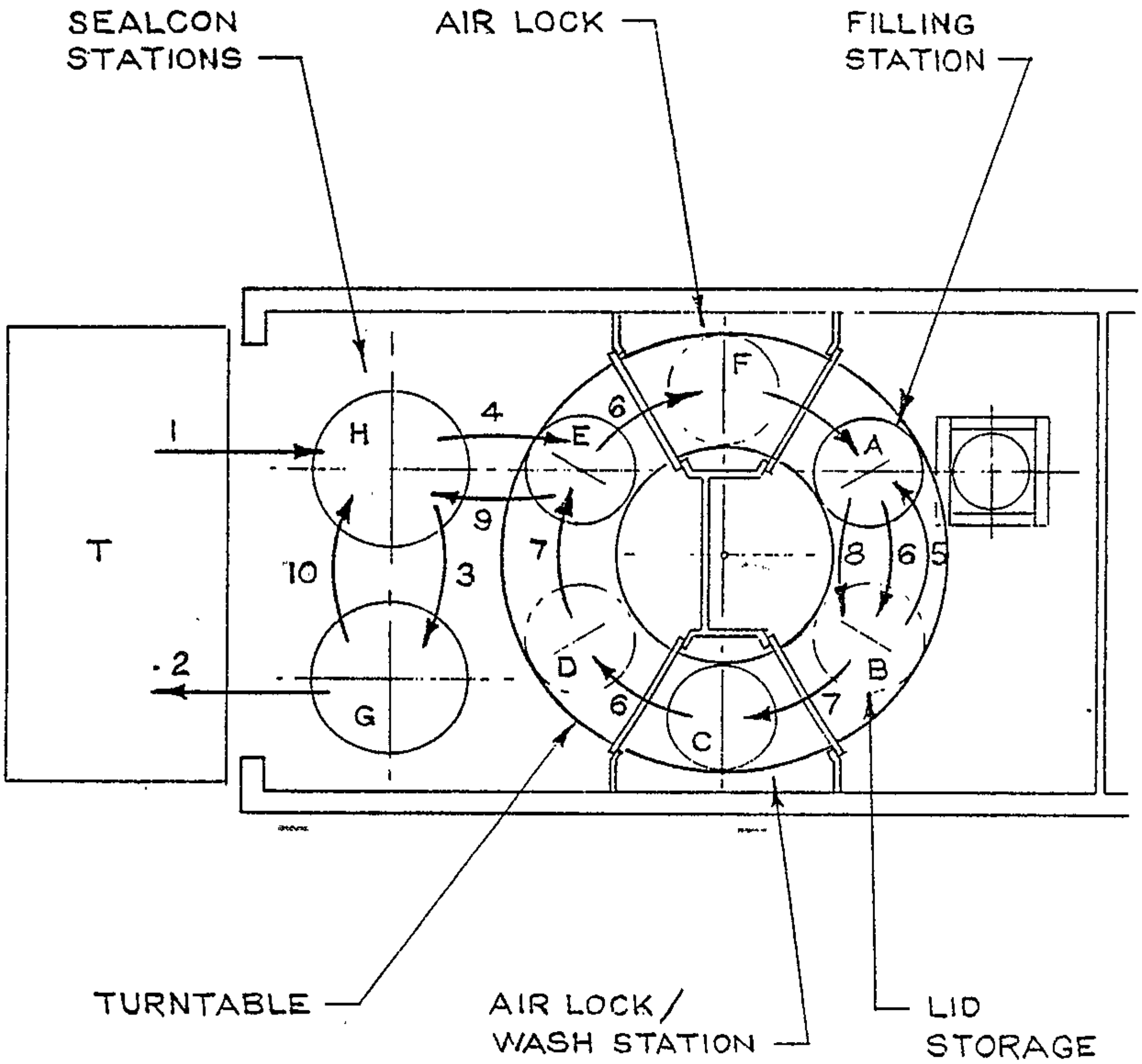

Figure 8-1 Container Handling Sequence

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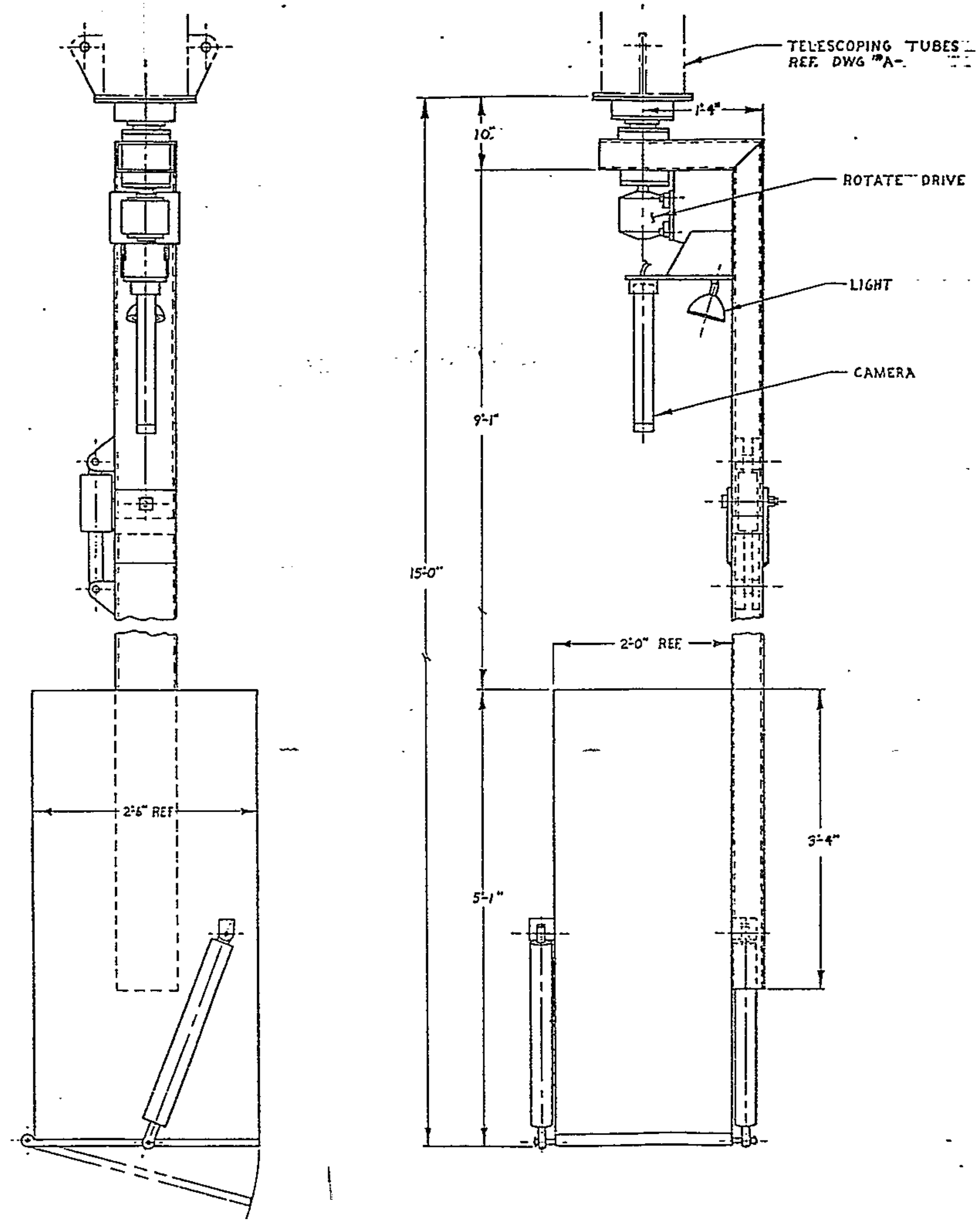

FIGURE 8-2

PROGRAMMED AND REMOTE SYSTEMS CORP.

MATERIAL	UNLESS OTHERWISE SPECIFIED TOLERANCES IN INCHES ARE:	ORIG. DATE 4-7-77	NAME MAT. ELEVATOR BUCKET ASS'Y	NEXT ASS'Y.
		DR JL		PROJECT NO. 5004
HEAT TREATMENT	FINISH	CHK		SHEET OF REV.
		ENG		DWG. NO. A-21673-D
		APP	SCALE $1\frac{1}{2}$" = 1' WT 1340	

AND Rails. Revised Extended Length & Wt

B Deleted Balloons Added Datum 5-3-77 R.A.L.

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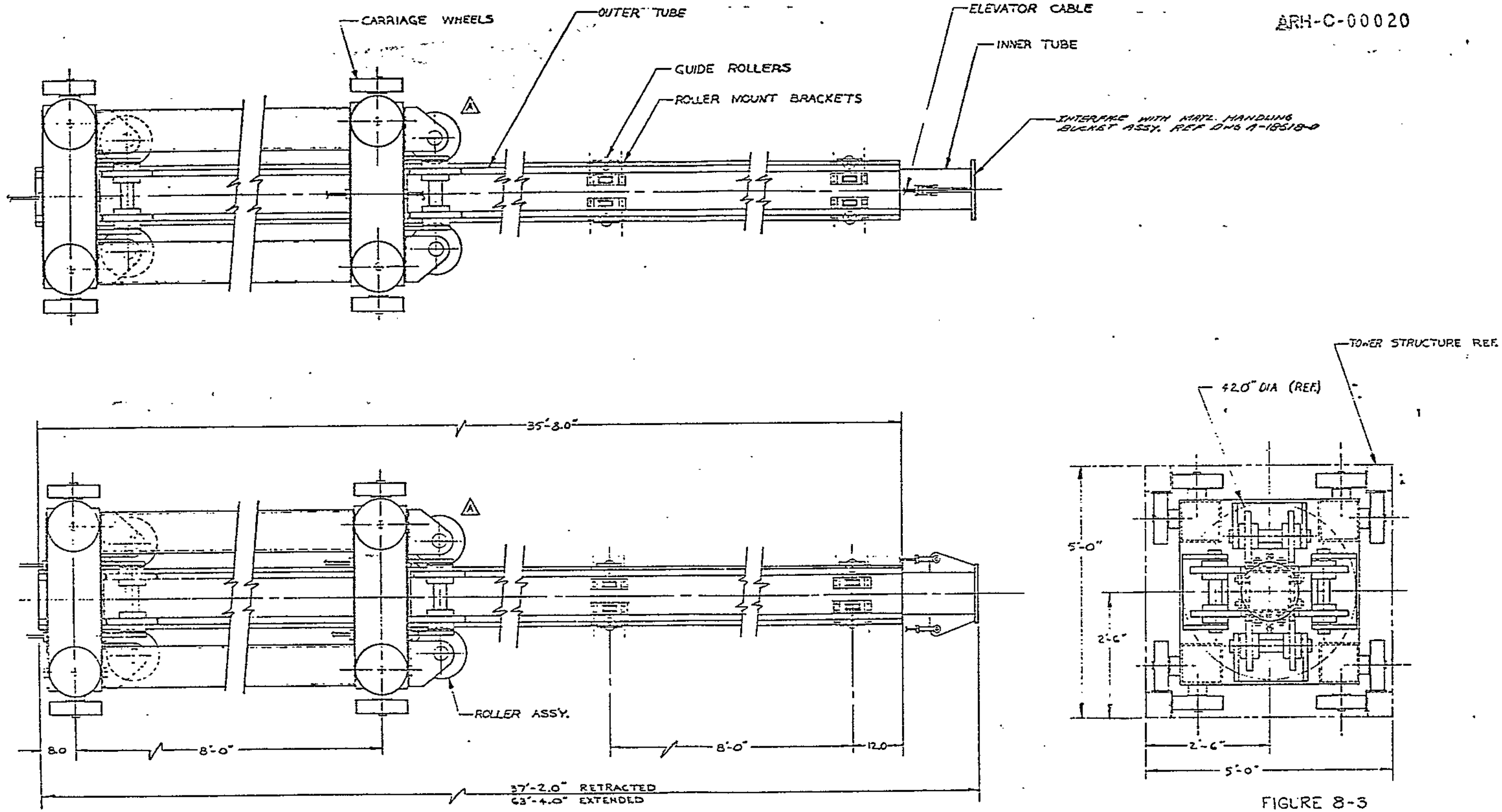

FIGURE 8-3

PROGRAMMED AND REMOTE SYSTEMS CORP.	
MATERIAL	FINISH
HEAT TREATMENT	
DWG DATE 10-17-75	NAME: TELESCOPING TUBE ASS'Y MATERIAL ELEVATOR
NEXT ASSY.	PROJECT NO.
SHEET 1 OF 1	REV. B
DWG NO. A-18621-D	

8.1 CONTAINER HANDLING SEQUENCE (Ref: Figure 8-1)

A diagram depicting the handling sequence in the shipping cell is presented in Figure 8-1. This figure shows the movement of shipcons, sealcons, and lids as the filling and loading operations proceed during a complete cycle. To explain the operating cycle it is assumed that we start at the point where an empty shipcon is at the filling station "A" being filled and its lid is at "B". There is a filled shipcon at the airlock/wash station "C". Also, there is a loaded and lidded sealcon at "G". A truck has arrived at "T" with a set of empty containers. The steps in the sequence are as follows:

Step 1- Empty containers moved from truck into the shipping cell. T to H

Step 2- Loaded sealcon moved onto truck. G to T

Step 3- Lid removed from sealcon. H to G

Step 4- Empty shipcon placed on turntable. H to E

Step 5- Lid placed on filled shipcon. B to A

Step 6- Turntable rotated to move filled shipcon to station B and empty shipcon to airlock. A to B and E to F

Step 7- Turntable rotated to move filled shipcon to wash station and empty shipcon from airlock to filling station. B to C and F to A

Step 8- Lid removed from empty shipcon. A to B

Step 9- Filled and washed shipcon loaded into sealcon. E to H

Step 10- Lid installed on sealcon. G to H

At this point station G is vacant and ready to receive a set of empty containers when the next truck arrival occurs. The loaded sealcon at H is ready to go onto the truck.

8.2 MATERIAL ELEVATOR (Ref: Figures 2-1 & 2-2)

The elevator travels through one of the tank's 42-inch diameter risers which is located 20 feet 9 inches off center. The elevator is mounted in a tower supported by the main support frame. A telescoping tube hoist similar to that used for the mining boom, provides vertical travel. A rotate assembly on the bottom of the inner telescoping tube allows the bucket to be rotated about its vertical axis. The bucket is supported by an offset yoke which allows free access to the bucket by the mining boom tool. As the elevator is raised, the entire assembly is removed from the tank.

The control system, upon operator initiation, automatically raises the elevator, dumps the waste material, flushes the bucket with water, and returns the bucket to the preset elevation in the tank. To eliminate excessive vertical motion by the boom on each digging cycle, the bottom position of the elevator periodically is lowered by the operator, to keep it a nominal distance above the material level. The mining boom automatically goes to the elevator level for unloading.

8.2.1 SPECIFICATIONS

1.	Rated load capacity	24 cu. ft. (2546 lbs. @ 1.7 gm/cc)
2.	Operating hydraulic pressure	2000 psi
3.	Approximate weights	
	a. bucket and supporting yoke ass'y	1340 lbs.
	b. telescoping tubes, carriage and miscellaneous	9710 lbs.
	Total Weight	13,596 lbs.

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4. Motion specifications

Motion	Type of Actuator	Travel	Speed
Elevator lift	Electric drive hoist	59 ft.,to dump	60 Ft./Min.
Bucket rotate	Hydraulic rotary vane actuator	180 degrees	2 RPM
Bucket pivot	Hydraulic cylinder	30 degrees	1.0 Sec.
Door operation	Hydraulic cylinder	90 degrees	2.5 Sec.

8.2.2 BUCKET ASSEMBLY (Ref: Figure 8-2)

The bucket assembly shown in Figure 8-2 has a capacity of 24 cubic feet, or approximately 2546 pounds of material having an average specific density of 1.7 gm/cc.

A bottom-dumping bucket is used. For unloading, the supporting yoke has a pivot motion with a hydraulic cylinder actuator to bring the bucket over the shipcon before the bottom door is opened. The door is operated by two hydraulic cylinders. A light and a TV camera are mounted on the yoke to observe bucket filling.

8.2.3 TELESCOPING TUBE ASSEMBLY (Ref: Figure 8-3)

The telescoping tubes have two moving sections, one of which is mounted in a carriage which travels up and down the elevator support tower. This outer tube moves in the carriage on guide rollers. The second tube travels up and down inside of the outer tube guided by rollers. Hoist cables attached near the bottom of the inner tube, pass over sheaves mounted to the top of the tower and down the outside of the tower to an electrically driven winch on the roof of the main structure. The

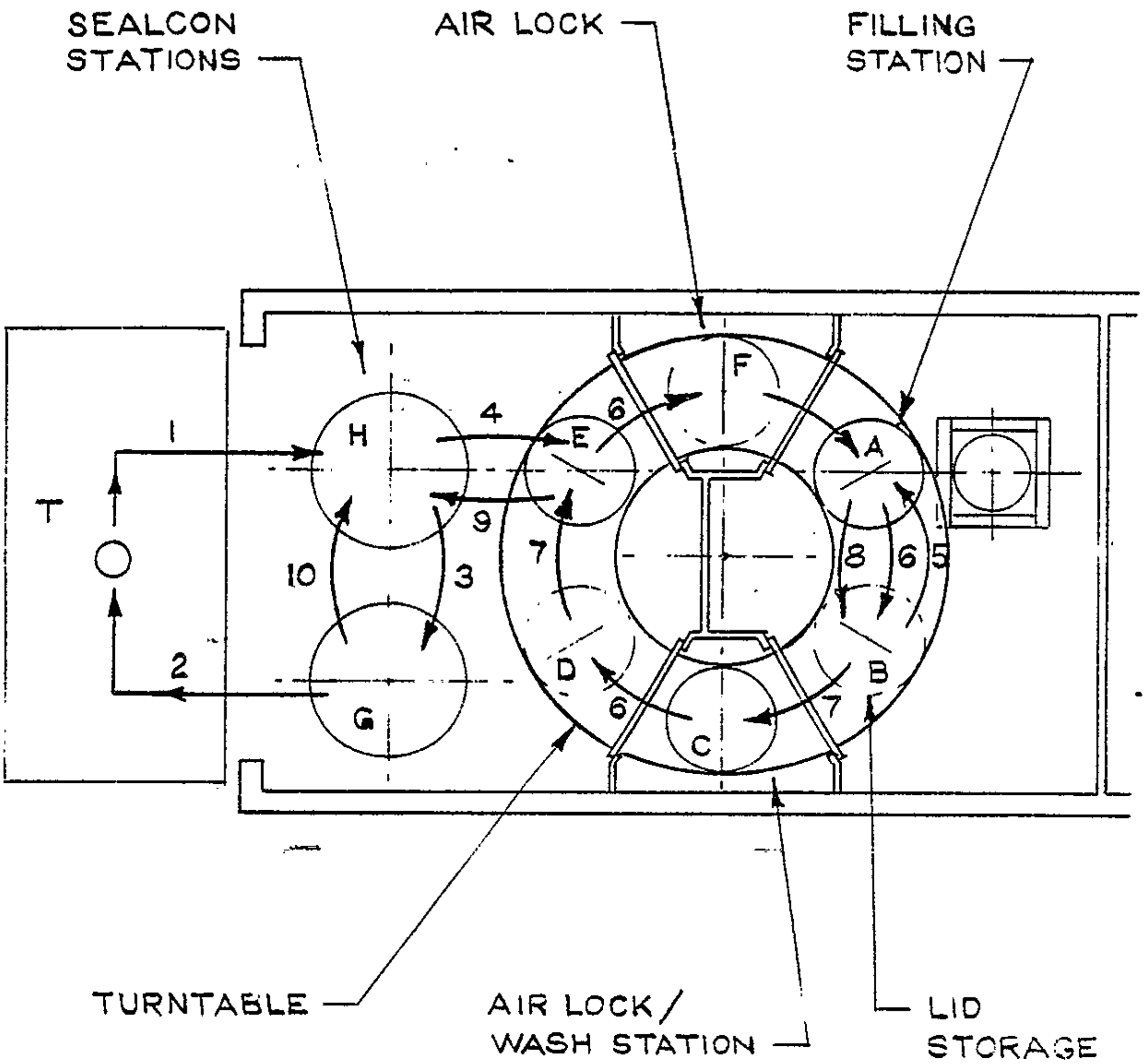

Figure 8-1 Container Handling Sequence

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telescoping tubes provide enough vertical travel to allow the elevator to be completely withdrawn from the tank for unloading and to provide the necessary in-tank travel for loading.

8.2.4 SLURRY DEVICE

ARHCO is studying a device for producing a slurry of the waste material and pumping this slurry out of the waste tank. This device would be used in place of the material elevator bucket and support frame below the rotate drive on the telescoping tubes.

The estimated weight of the slurry device loaded with waste is 5,500 pounds, which is slightly greater than the estimated weight of 4,890 pounds for the support yoke and loaded bucket, as proposed. The hoist cables and hoist are sized to lift the 5,500 pounds plus the 9,360 pounds contributed by the telescoping tube and carriage assembly with ample margin of safety.

8.2.5 MATERIAL ELEVATOR WASHDOWN

The material elevator tower serves as a chamber in which the elevator can be washed. When the elevator is at its uppermost position, a door at the base of the tower can be closed. In this manner the wash water is collected and returned to the wash water tank.

There are a number of spray nozzles located at appropriate positions within the tower which direct warm water at the elevator. When washing is completed, the door at the base of the tower is opened and hot air is blown over the elevator to dry it.

8.3 <u>20-TON CRANE</u> (Ref: Figure 2-1 & 2-2)

A 20-ton overhead crane in the shipping and receiving room is used to unload containers from the transport tractor/trailer; remove the sealcon lid; lift the shipcon from inside the sealcon and place the shipcon on the turntable; pick up a filled shipcon from the turntable and place it in a sealcon; place the lid on the sealcon and load the container set onto the trailer.

The 20-ton crane bridge runs on rails which are a part of the waste retriever structure. The rails extend beyond the shipping and receiving room such that the crane can be moved over the transport trailer. The hoist is mounted on a trolley which runs on the bridge to provide coverage of the entire shipping and receiving room.

A latch tool described in Section 8.6 of this report is attached to the crane lifting block.

A four-part rope is used on the crane to provide the required lifting capacity and to prevent undue rotation of the latch tool and items carried by the crane.

The 20-ton crane can be moved into the shielded filling room for special handling functions.

8.4 <u>TURNTABLE</u> (Ref: Figure 2-1 & 2-2)

The turntable is used to move shipcons between the shipping/receiving area and the container filling area of the Prototype Retrieval System.

The concept design of the turntable uses a rotary section 20 feet outside diameter and 9 feet inside diameter. The rotary section is flat on top and is supported and guided by wheels around the outer and inner peripheries. It is driven by a motor and gear reducer located in a housing on the side of the system main support structure. Angular position control is by means of cams located on the outside diameter of the rotary section which actuate limit switches mounted in the drive housing. These provisions enable the drive motor, gear reducer and limit switches to be inspected and replaced without entering the shielded filling area.

The turntable has a load capacity of 45,000 pounds, adequate to support three filled shipcons. Rotational speed is one revolution per minute. As the turntable moves a filled shipcon through the wash station between the filling and shipping and receiving rooms, the exposed surfaces of the turntables are washed.

8.5 SHIELDED AIR LOCKS AND CONTAINER WASH STATION

Two combination shielded air locks provide for normal passage of shipcons into and out of the shielded filling room thus maintaining shielding and air flow control between the shielded and unshielded areas.

Each air lock has two shielded doors which are actuated by hoists on the top of the lock housing. The shielded housing is large enough to accommodate a shipcon, with both doors closed. The locks are arranged such that at least one of the two doors on each lock is closed at all times. Interlocks prevent both doors on a lock being opened simultaneously unless over-ridden to accommodate special situations.

One of the locks contains a washdown station for cleaning filled and capped shipcons. The washdown device is timer controlled and operates only when both doors are closed. The

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interior of the lock, and the turntable which carries the ship-cons also are washed to prevent buildup of contaminated material. Hot air is used to dry the shipcon before it is moved from the lock.

A shielded door between the two locks can be opened for movement of large objects into and out of the filling room. The exterior door of the shipping and receiving room must be closed when the shielded door is open to maintain control of air flow.

8.6 LID HANDLING MACHINE AND LIFTING TOOL (Ref: Figure 8-4)

Figure 8-4 shows the lifting tool used to operate the locking and sealing mechanism used on the lids of both the shipcon and the sealcon. It also serves as the device by which the containers are lifted.

The tool is used on both the lid handling machine and the 20-ton crane.

Two fingers at the center of the tool enter a recess in the container lid (Ref: Figure 11-1 Waste Container). An air cylinder actuates a plunger which spreads the fingers to engage a ledge in the recess, so that the lid or the entire container, can be lifted. The hook shape of the fingers assures that the fingers cannot be opened when they are supporting a load. With no weight on the tool, the air cylinder actuated plunger disengages the fingers.

A pin on the tool engages the locking-bar drive-ring on the lid as the tool is lowered onto the lid. An air cylinder moves the pin so as to rotate the drive-ring to either extend or retract the locking bars. The ends of the locking bars engage with mating recesses at the upper edge of the container.

The locking bars have ramped surfaces at the ends to force the lid down against a sealing gasket. Holes in a bar on the tool engage locating pins on the container lid to position the tool and absorb the latching and unlatching torque.

The lid handling machine is mounted in the filling room and is used to remove the lid from a shipcon which is at the filling station next to the material elevator, move the lid to a storage position while the shipcon is being filled, return the lid and place it on the shipcon.

The lid handling machine has a horizontal member with the latching tool described above located at its outer end. The horizontal member is driven vertically to engage and disengage with a lid and to raise and lower a lid. The horizontal member also is pivoted to move the lids between the filling station and the storage location.

The lid handling tool on the 20-ton crane can be used as a remotely-operated connection with any item which has a latching recess in its upper surface, the same as is used on container lids.

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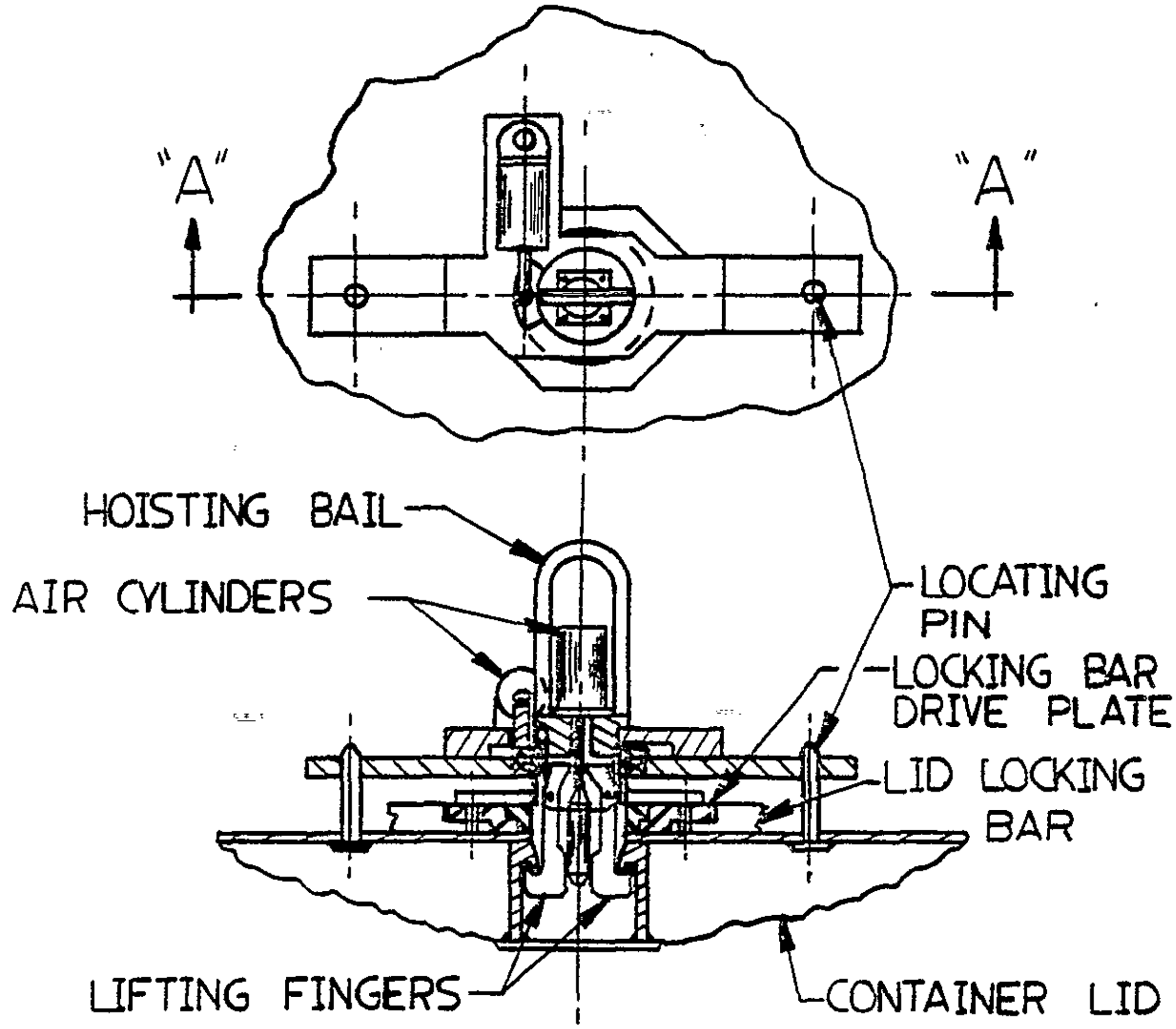

SECTION "A"-"A"

LIFTING TOOL

FIGURE 8-4

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9.0 MAINTENANCE ROOM EQUIPMENT

9.1 TOOL MAINTENANCE CART (Ref: Figure 2-1 & 2-2)

The tool maintenance cart is a moveable fixture for holding mining boom tools and other items while they are being washed in the wash station or worked on in the maintenance room. The base of the cart is approximately 4 feet by 4 feet in size. There are two uprights approximately 10 feet high which are topped with saddles for receiving the support arms incorporated in the adapter end of each tool.

Wheels on the base of the cart run on rails in the floor of the wash station and the maintenance room. An arm on the base is connected to a drive chain mounted between the rails. The drive unit is below the floor of the maintenance room but located so as to be accessible for servicing. The primary control for the drive unit is located on a wall of the maintenance room.

9.2 TWO-TON MONORAIL HOIST (Ref: Figure 2-1 & 2-2)

A two-ton monorail hoist is located in the maintenance room. The monorail is centered above the rails for the tool maintenance cart so that tools or other items can be placed on or removed from the cart.

The monorail is mounted high in the maintenance room so that when the hook is fully raised the two-ton crane and the Model 3000 manipulator will be able to pass under it. With the overlapping of the hoist and crane it is possible to pick things up with the crane that have been set down by the hoist, or vice versa. The monorail extends over the wash station so that items can be lifted out of the wash station if necessary.

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10.0 SPECIAL HANDLING & VIEWING PROVISIONS

The basic handling equipment incorporated in the Prototype Retrieval System conceptual design, described in detail in other sections of this report, includes a 20-ton overhead crane in the shipping and receiving area and a 2-ton overhead crane in the boom area.

The shipping/receiving room, filling room, mining boom room, and maintenance room of the System are separated by shielding and air-control walls as required for safe operation. In normal operation, the 20-ton and 2-ton overhead cranes operate only in their assigned areas.

To provide versatility and redundancy during special situations such as System start-up, shut down, moving between waste tanks and major equipment maintenance, the handling equipment can be utilized to perform tasks beyond their routine operations.

Two remotely operated shielding/air lock doors are provided between the shipping/receiving room and the shielded filling room, to allow the 20-ton overhead crane to move into the filling room. The upper door provides clearance for the crane bridge and a lower door, located between the two shielded air locks allows large objects to be handled by the crane. While these doors are open, air control is provided by keeping the shipping/receiving room outside door closed.

In a similar manner, upper and lower remotely operated doors are provided between the filling room and the boom room, to allow the 2-ton overhead crane to enter the filling room. The 2-ton and 20-ton cranes have an overlapping coverage in the filling room so that an object carried by one can be set down and picked up by the other. The 2-ton crane is capable of moving under both the elevator and the mining boom when they are fully retracted.

Side and top doors on the tool washing area and an upper door between the boom room and the maintenance room, allow the 2-ton overhead crane to enter the maintenance room. Coverages of the 2-ton overhead crane and the 2-ton monorail hoist in the maintenance room overlap so that an object carried by one can be set down and picked up by the other. Air control is maintained by closing the maintenance room exterior doors while the inner doors are open. Interlock control is provided on the various doors described above so that doors can be opened only in the proper sequence as necessary to control air flow and prevent escape of airborne radioactive particles.

To provide additional remote handling capability, an overhead bridge-mounted, electro-mechanical manipulator which travels on the same runway rails as the 2-ton overhead crane is provided.

During normal operation of the Prototype Retrieval System, the manipulator is stored over the personnel room, adjacent to the maintenance room.

By use of the inter-cell doors described above, the manipulator can work in and between the maintenance room, boom room and filling room.

The manipulator is a versatile handling device which has been used successfully in many remote handling applications. With its interchangeable hands and tools, it is capable of performing most manipulative tasks which can be done by a person.

The manipulator provides an important back-up system to the basic handling equipment and provides a means of performing special functions which may develop such as recovering any dropped material or components, maintaining and replacing components or equipment and cleaning the interior of the waste retriever should contamination reach excessive levels. Wash water hoses installed in the filling room and the mining boom room, the areas where contamination is most likely to occur, can be picked up and operated with the manipulator. The manipulator can be washed down in the tool wash area after each use. Floor drains in these rooms return the water to the wash water system. Removable roof sections are provided in the major areas of the waste retriever. With the System shut down and cleaned, the roof sections allow a truck mounted crane to install and remove major items of equipment.

Normal viewing in the filling room, the shipping/receiving room, and boom room is provided by TV cameras. The equipment in these areas normally is operated from the control center. To provide additional and back-up viewing, shielded windows are provided in the walls which separate the personnel room from the maintenance room, and the maintenance room from the boom room. Also, shielded windows are provided at each of the local control stations in the personnel corridor which runs along one side of the main structure.

These windows can be used on at least an intermittent basis to permit direct viewing of all of the remote functions of the Prototype Retrieval System.

10.1 MANIPULATOR-MODEL 3000

A bulletin describing the Model 3000 Manipulator and giving its specifications is included in Appendix F of this report.

As used in the Prototype Retrieval System, the manipulator is supplied with a bridge which rides on the same rails as the 2-ton crane, a carriage and telescoping tubes to provide vertical travel. The telescoping tubes have a lift capacity of 1000 pounds.

In addition to the rectangular coordinate travel (X,Y,Z) provided by the bridge, carriage and telescoping tubes, the manipulator has seven motions; shoulder rotate, shoulder pivot, elbow pivot, wrist pivot, wrist rotate, wrist extension, and grip. These motions enable the manipulator to perform a wide variety of tasks. The manipulator has an outreach of 45 inches and a load capacity of 150 pounds at the hand. It is supplied with a parallel jaw hand having an opening of 5 inches and a grip force of 0 to 200 pounds and a hook hand having an opening of 3 inches and grip force of 0 to 800 pounds. A tool power receptacle on the manipulator allows remote operation of powered tools (drills, impact wrenches, screw drivers, etc.) held by the hands. The hands and tools can be interchanged remotely.

The manipulator is sealed to allow washdown, and corrosion resistant finishes are used on the external surfaces.

A 1000 pound capacity hook, fastened to the shoulder housing and easily reachable by the hand is used in moving objects which are beyond the load capacity of the hand.

All functions of the manipulator are operated remotely from a control console.

11.0 WASTE CONTAINERS (Ref: Figure 11-1)

The shipping container arrangement used in this report uses a shielded shipping container (shipcon) of 96 cu. ft. capacity, a sealing container (sealcon) which encloses the shipcon and an enclosure on the transport trailer which encloses and secures the shipcon/sealcon set during transport. The shipcon and sealcon are shown in Figure 11-1.

One 96 cu. ft. load of material per trailer load is carried from the tank site to the processing plant. A set of empty and cleaned containers is carried on the return trip.

Some basic considerations used in the container configuration are:

- No expendable liners
  Because of the large number of shipments to be made, expendable liners would be expensive and would contribute significantly to the waste material to be processed.
- Double container
  To provide additional assurance against an accidental release of radioactive material, two sealed containers are used. The shipcon which contains the material is filled, capped and washed before being placed in the sealcon. The sealcon does not enter the loading or unloading areas.
- Shielding
  Based on preliminary information supplied by ARHCO it appears that 1.5" lead is adequate to shield the containers. The proposed design uses 1.5" lead on the sides, top and bottom of the shipcon.
- Sealing
  Both the shipcon and sealcon use a rotary actuated

clamping mechanism which can be operated by the same device. Gaskets which can be replaced periodically as required at the processing plant are used on the shipcon and sealcon lids.

- Container Cleaning

  Both the shipcon and sealcon are washed at the processing plant before they are returned to the waste retriever.

  The external surfaces of the shipcon are washed at the waste retriever before the shipcon is placed in the sealcon.

- Cooling

  Information furnished by ARHCO indicates that the heat generated by the radioactive material is low enough that no separate means of heat dissipation is required on the containers.

- Shipping Restraints

  The routes from tank sites to the processing plant are considered to be non-public-access roads located within the Hanford Reservation. Truck speeds will be kept low by governor limitation. The containers will withstand credible accidents under these conditions without leaking, but do not meet the requirements for shipping radioactive materials over public highways.

- Container Standardization

  It is proposed that all contaminated materials shipped from the Prototype Retrieval System will be shipped in standard shipcons and sealcons. This includes high level waste material and debris which may be removed from a tank.

  The radiation rates of high level wastes can be controlled by using smaller quantities per shipment.

Debris moved from a tank, including rocks. metal and glass will be placed in standard containers for shipment to a facility which is equipped to segregate the materials and place them in suitable containers for disposal.

11.1 CONTAINER CONFIGURATION

After consideration of several container sizes and arrangements (Appendix A) the following configuration is used in the base design.

The in-tank material elevator has a capacity of 24 cu. ft. Four elevator loads equal to 96 cu. ft. are loaded into a single shipcon. Characteristics of the shipping container are presented below.

Shipcon Dimensions:

5' inside diameter x 5' height- (net inside)
Volume = $\pi/4 \ (5^2) \ (5) = 98.13$ cu. ft.
Outside height will be approximately 6'

Shipcon Estimated Weight:

Based on 1/2" thick steel

Cylinder, $\pi (60) (72) (.5) (.3) =$	2035 lbs.
Lid and Bottom, $\pi/4 \ (60)^2 \ (.5) \ (.3) \times 2 =$	848 lbs.
Top & Bottom Flanges, 2" x 3" steel	
$\pi (60) (6) (.3) \times 2 =$	680 lbs.
Fittings	500 lbs.
	4,063 lbs.

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Payload Weight (waste material)

96 cu. ft., specific gravity 1.7 material

96 (62.4) (1.7)	=	10,184 lbs.
Weight of container plus payload	=	14,247 lbs.

Shipcon Shielding Weight:

Lead weighs 0.45 lbs/cu. in. or 64.8 lbs/sq.ft./in.thick

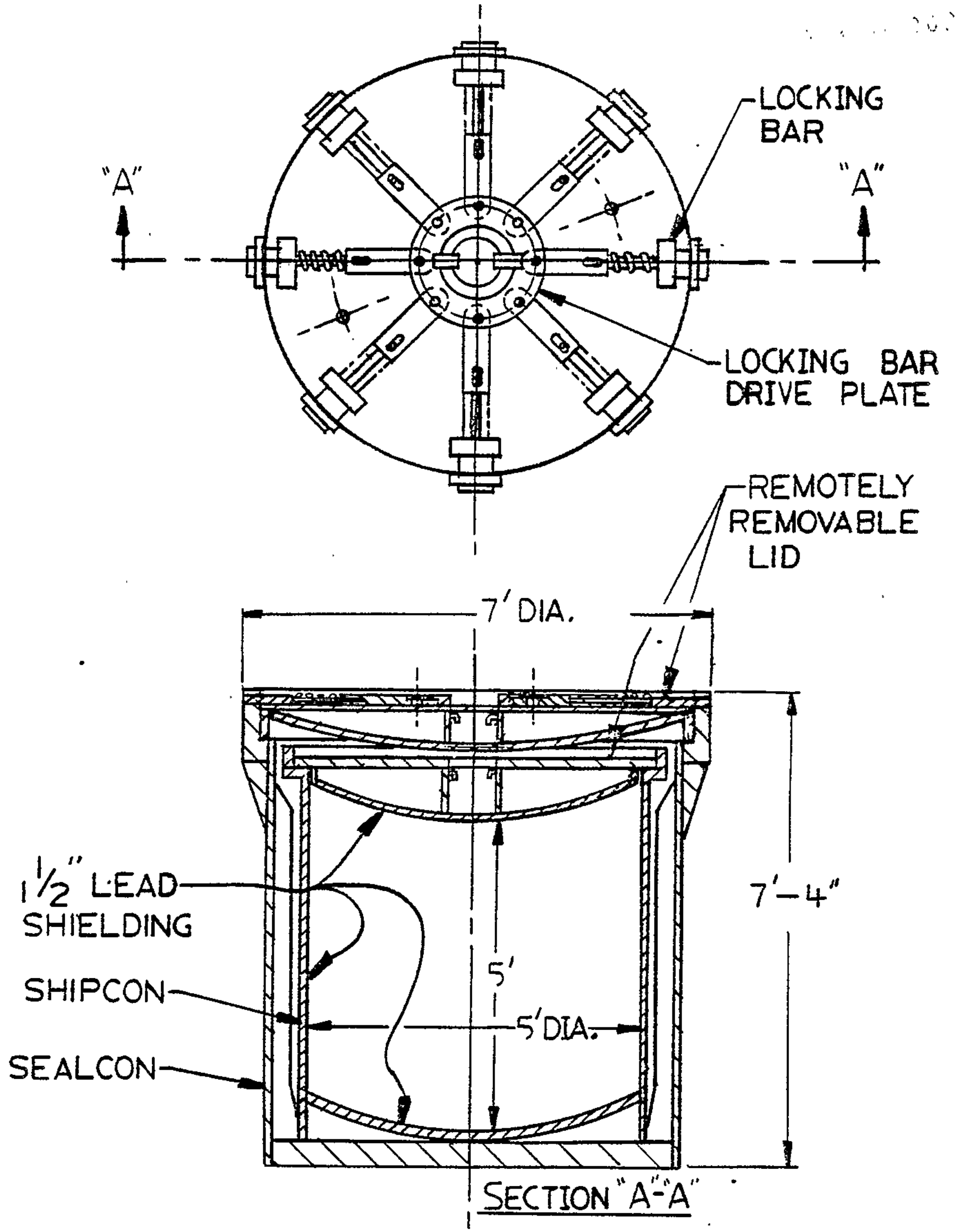
Area of sides $= \pi (5) \quad (6) = 94.2$ sq. fy.

Area of top & bottom $= \pi/4 \ (25) = 19.63$ (each)

Lead Thick.	Side Wt.	Top Wt.	Bottom Wt.	Total Wt.
1.0"	6,104 #	1,272 #	1,272 #	8,648 #
1.5"	9,156 #	1,908 #	1,908 #	12,972 #
2.0"	12,208 #	2,544 #	2,544 #	17,296 #

Based on 1.5" lead thickness:

Shielding Weight	=	12,972 lbs.
Container and payload weight	=	14,247
Total Gross Weight:		27,219 lbs.



WASTE CONTAINER

FIGURE 1.1-1

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Sealcon Estimated Weight:

6' inside diameter x 7' height - net dimensions

Based on 1/2" thick steel,	
Sides, (72) (84) (.5) (.3)	2,850 lbs.
Lid & bottom, /4 $(72)^2$ (.5) (.3)x 2= 610 x 2	1,220 lbs.
Top & bottom flanges , 2" x 3" steel	
(72) (6) (.3) x 2 = 407 x 2	814 lbs.
Fittings	600 lbs.
	5,484 lbs.
Gross Filled Weight of Shipcon and Sealcon = 27,219 + 5484	32,703 lbs.
Empty Weight of Shipcon and Sealcon	22,519 lbs

Thus, the capacity of the crane required to lift a set of full containers is approximately 16 1/2 tons. The 20-ton crane capacity which is proposed will provide an adequate margin for unexpected weight additions.

The estimated weight of the trailer mounted enclosure (Ref: Figure 12-2) is 5,000 lbs. This weight must be added to the gross filled weight of the container set to get the trailer load.

Total Estimated Trailer Load:

Containers + Waste Material	32,703 lbs.
Trailer Enclosure	5,000 lbs.
	37,703 lbs.

This appears to be a satisfactory load.

Container Summary:

	Total Wt.	Lid Wt.	O.D.	Height
Shipcon	27,219 lbs.	2200 lbs.	5'-9"	6'-0"
Sealcon	5,484 lbs.	900 lbs.	7'-0"	7'-4"

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12.0 TRANSPORT TRACTOR-TRAILER (Ref: Figure 12-1 & 12-2)

The general arrangement and dimensions of the tractor and trailer are shown in Figure 12-1.

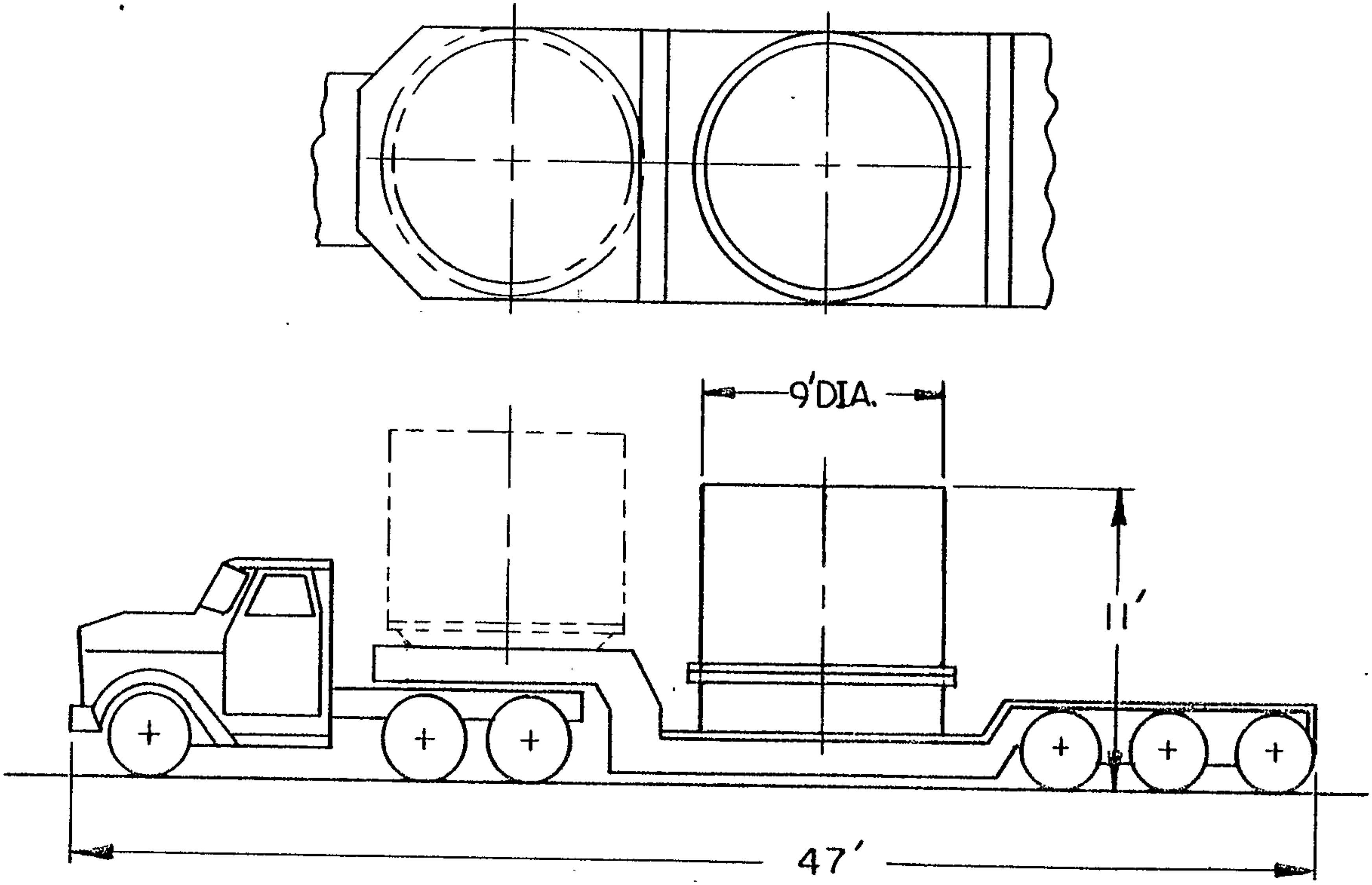
The trailer is a three-axle, double-drop, well-type, lowboy trailer. It is a high-capacity, low-ground-load unit. The lowboy construction minimizes the height of the center-of-gravity of the load, and is compatible with the elevations of the waste retriever shipping and receiving room floor.

The container enclosure which is secured to the bed of the trailer is shown in more detail in Figure 12-2. The enclosure is cylindrical with a removable upper section. The sections separate at a plane 24 inches from the bottom such that the fixed base section serves as a receptacle into which the container set is positioned during loading. Manually operated latches, incorporated in the mating flanges of the two enclosure sections, are used to secure the sections together after the upper section has been placed on the base. Energy absorbing materials in the enclosure,limit the load imposed by credible accelerations on the sealcon and shipcon.

The upper section of the enclosure has a recess in the top exterior at the center which mates with the lifting tool on the 20-ton crane. When removed, the upper section is stowed on the forward platform of the trailer. As the container set is lifted out of the enclosure base, it can be moved either in a direct path into the shipping and receiving room or in a path passing to the rear of the trailer before moving into the room. The pattern followed will depend upon which sealcon position in the shipping and receiving room is open. The tractor-trailer combination has the advantages over a flat bed truck of carrying the load at a lower elevation and of the ability of exchanging tractors for maintenance or in the case of malfunction.

A special 10-foot wide trailer extends beyond the container enclosure and provides additional assurance against the trailer overturning.

It is recommended that a minimum of two transport units be provided for each tank site being operated.



TRANSPORT TRACTOR -TRAILER

FIGURE 12-1

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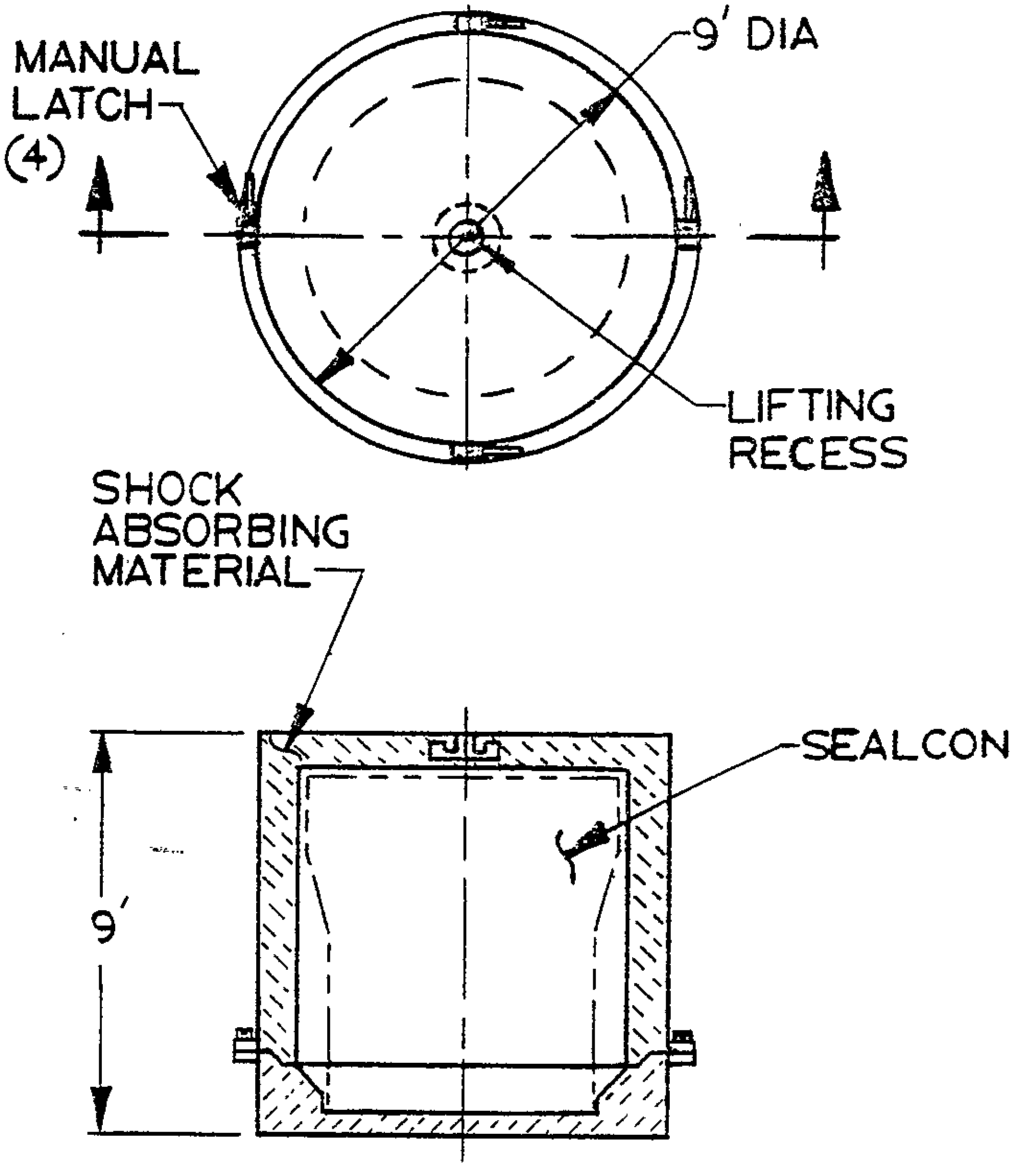

TRAILER - MOUNTED ENCLOSURE

FIGURE 12-2

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13.0 SHIELDING

There are two aspects of the retrieval System design which afford protection to personnel from exposure to hazardous radiation. One is that all of the equipment is remotely operated so that personnel are normally in the control center which is removed from the main structure. The other is the shielding provided by materials incorporated in the System structure and the waste material containers. Because the system must be portable, the overall weight has been minimized by judicial use of lead for shielding, confining its application to only those regions where shielding from the structure itself is inadequate.

13.1 SHIPCON SHIELDING

The largest quantity of waste material to be handled will occur in a filled shipcon. By placing the shielding close to the volume of waste, the amount of shielding is minimized. Therefore, a 1.5-inch layer of lead is incorporated in the walls, bottom and lid of each shipcon. Consequently, once the shipcon has been lidded and washed down there is no need for additional heavy shielding outside the shipcon. Actually, the steel in the walls of the shipping room will provide additional protection until the loaded and washed shipcon is placed in the sealcon and from then on the steel walls of the sealcon will provide additional shielding.

13.2 SHIPPING AND RECEIVING ROOM SHIELDING

Filled shipcons entering the shipping room from the filling room will be clean after having passed through the wash station. The turntable is also washed clean as it passes through the wash station. The shipcons themselves are well shielded to absorb radiation eminating from the waste material inside. Empty containers being returned to the shipping room from the processing plant will be clean after having been washed at the processing plant. Consequently, since only cleaned empty containers and lidded and cleaned filled shipcons are handled in the shipping room there is no requirement for additional shielding in the exterior walls of the shipping and receiving room.

13.3 FILLING ROOM SHIELDING

The most critical requirements for shielding occur in the filling room where waste material is being dumped from the elevator bucket into the shipcon. Here significant quantities of unshielded waste material are being handled in a "dirty" operation which will very likely result in contamination of walls and equipment in the room. Consequently, all four walls of the filling room are lined with 1.5 inches of lead up to a height of 17 feet.

In addition, the sides of the elevator tower are lined with 1.5-inches of lead up a distance of 7 feet from the bottom of the tower which is at the 17 foot level. Thus, at the tower, the shielding is continuous up to a height of 24 feet. This is necessary because the elevator bucket is raised to this height to provide clearance for the 2-ton crane and for elevator washing.

For the air locks used in conjunction with the turntable, all walls and both doors of each air lock are lined with 1.5 inches of lead. In this way, the shielding remains inviolate even though the doors of the air lock are operated. Interlocks are provided so that both doors cannot be opened simultaneously.

13.4 MINING BOOM ROOM SHIELDING

Only minimal contamination will exist in the mining boom room. The mining boom will be washed after it is withdrawn from the tank. The mining tools will be washed in the tool washdown chamber after removal and prior to storage. Because only very small quantities of radionuclides will exist in this room, only 1/8 inches of lead is used to line the two exterior walls and the interior wall between the boom room and the maintenance room. This shield extends from the floor up to a height of 17 feet.

13.5 MAINTENANCE ROOM SHIELDING

Equipment entering the maintenance room from the mining boom room is carefully decontaminated in the wash chamber prior to entry. Consequently, there is no contamination in the maintenance room, and there is no requirement for adding shielding material to the walls of this room. However, the walls and top of the wash chamber are lined with 1/8 inches of lead.

13.6 EXTERNAL GROUND/STRUCTURE INTERFACE SHIELDING

Since the main structure does not rest directly on the ground, there is a requirement for shielding around the regions above the two 42-inch risers. This is provided by shielded air seals between the ground and the base of the main structure.

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14.0 TV VIEWING AND LIGHTING SYSTEM (Ref: Figure 14-1)

Television viewing is provided by TV cameras in the operating areas of the Prototype Retrieval System and in the underground waste storage tank. The monitors for all cameras are located in the trailer control center.

The TV system consists of 11 TV cameras and monitors, 11 camera control units and 5 camera positioning control panels.

Television viewing in the shipping room, filling room and boom room is used to observe general operating conditions as well as to assist in tool changing and maintenance. Two cameras are mounted in each room to give two views. Lighting is provided by ceiling mounted fixtures.

In-tank viewing and lighting is provided by free standing units located over 12" diameter tank risers. A TV viewing and lighting unit is shown in Figure 14-1.

A minimum of three and preferably four units would be used on each tank.

The TV unit consists of a structure approximately 4'wide, 5' deep and 29' high mounted on a 12' square base. The corners of the base will be secured by "dead-man" anchors, or weighted, so that the structure will withstand the maximum wind loads.

The structure has a personnel door to allow maintenance of the TV camera, lights, hoist and cable take up. A wall mounted ladder provides access to all of the equipment in the structure. A sealing ring around the riser keeps the interior of the unit at the slightly negative tank pressure during operation. A sealing/shielding cover is placed over the riser during maintenance.

The TV camera and lights are mounted to the bottom of a three section telescoping tube which gives a vertical travel of 45 feet. This travel lowers the camera to within 13 1/2 feet of the bottom of a tank and raises it to a position where it can maintained or replaced. The telescoping assembly is made up of three square tubes. An electrically powered hoist is connected to the inner tube by a 1/4 inch diameter steel cable.

The TV camera mounting has a pivot (tilt) motion of 180 degrees starting at 30 degrees above horizontal and a rotate (pan) motion of 360 degrees to provide viewing of all parts of the tank. These motions are electrically powered.

A bank of lights above the TV mounting is used for in-tank illumination.

The cables for the TV camera, positioning motions and lights are run along the exterior of the telescoping tube for ease of installation and maintenance. The cable take-up system uses a pair of large sheaves mounted near the top of the structure and a lower pair of counterweighted moving sheaves around which the cables pass to form a four-part cable. The lower sheave pair moves one-fourth the distance of the telescoping tubes allowing the cables to be housed in the structure without the use of slip-rings.

A lifting bail on top of the structure permits the TV unit to be moved from tank to tank by a truck mounted crane.

A TV camera is mounted on the elevator to view the material container as it is being filled and discharged. This is to assure that the material is transferred properly from the mining boom to the container and that the container empties fully.

Each of the TV positioner control panels controls two TV positioners. Variable voltage DC motors are used for precise camera positioning. A digital readout is used to display the vertical position of the in-tank cameras.

The in-tank viewing unit shown in Figure 14-1 could also be used for conventional photography within the tank. In this case the TV camera would be replaced with a conventional camera and strobe light so that positioning would be accomplished in the same manner as for the video camera.

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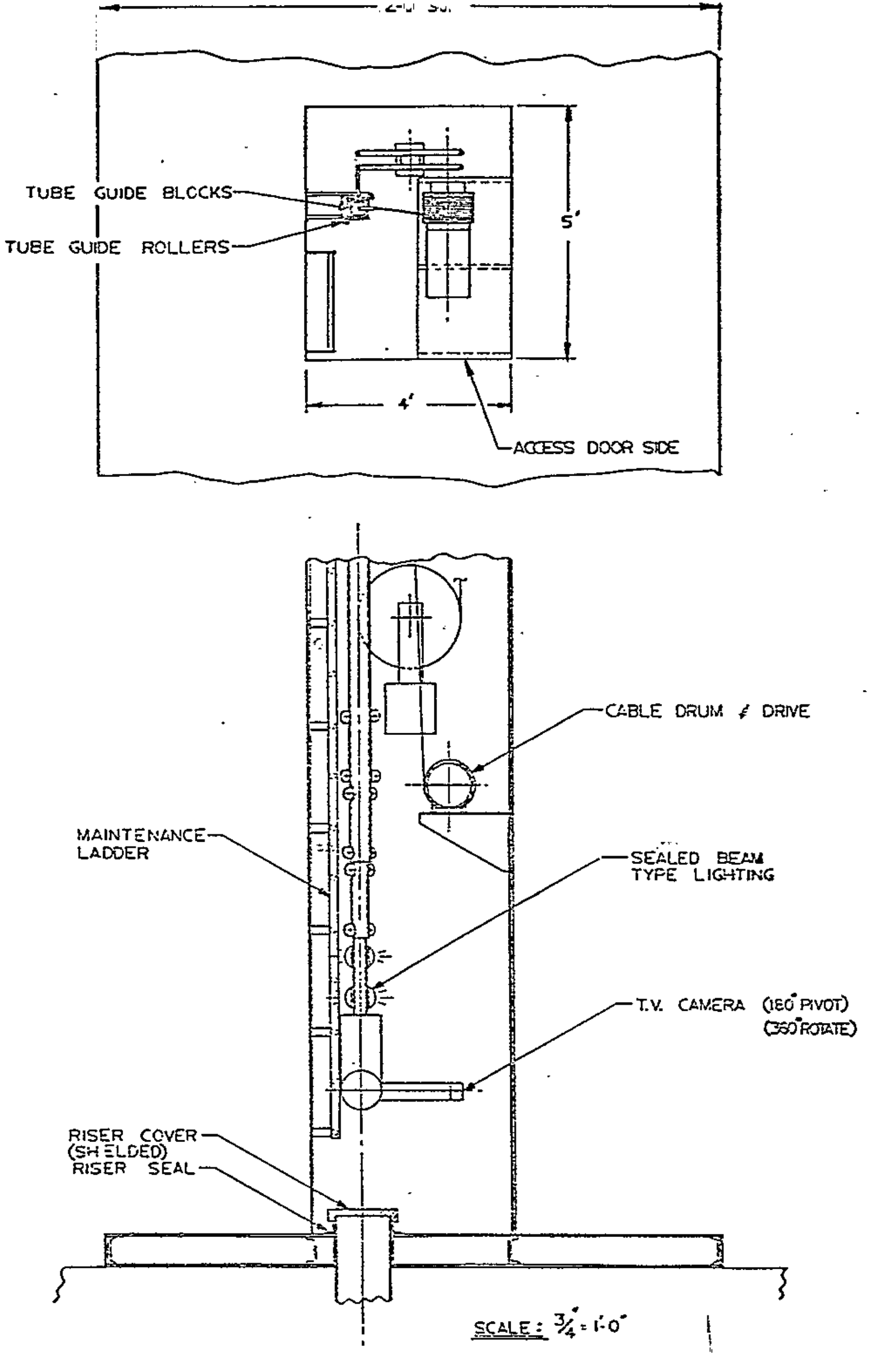

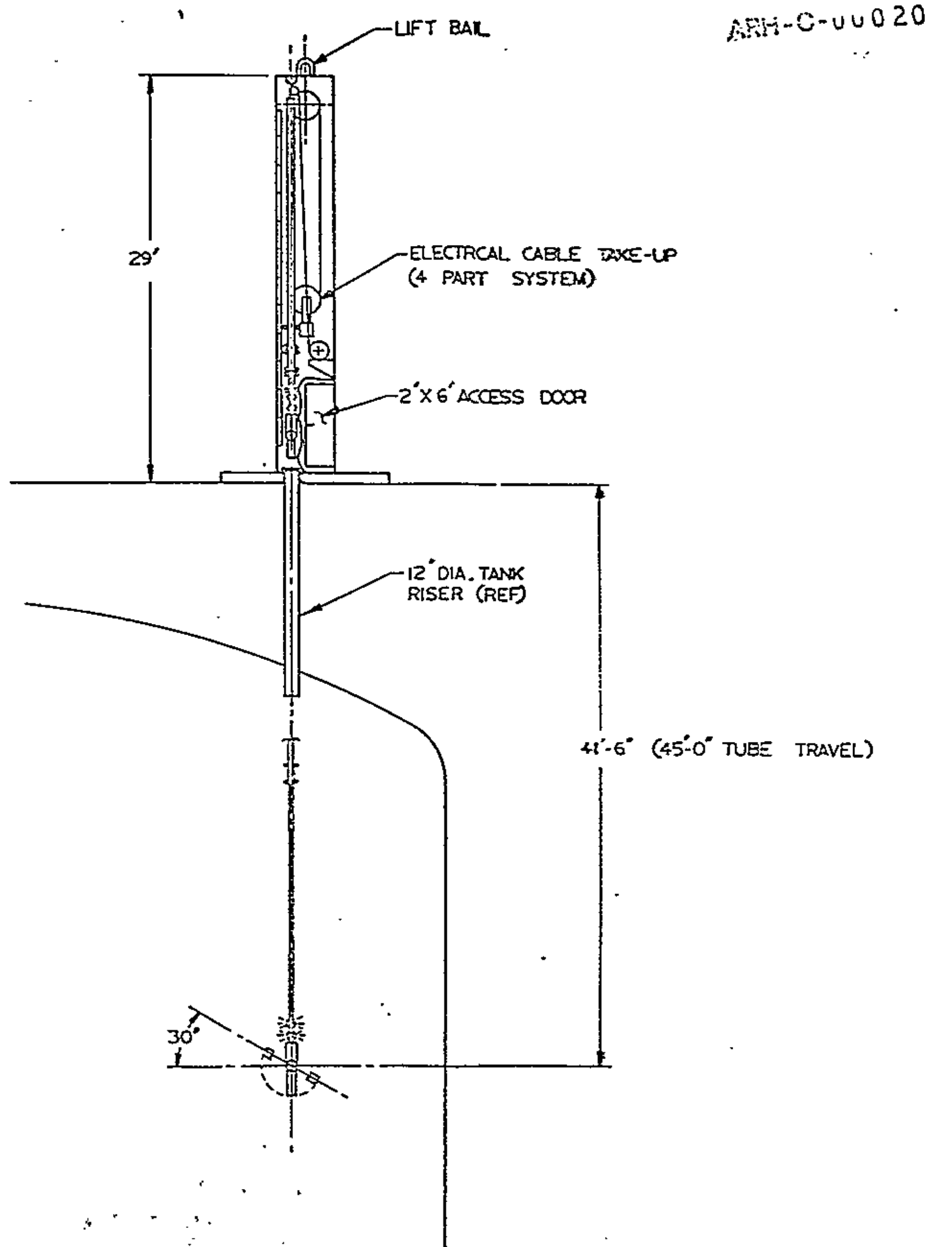

FIGURE 14-1

PROGRAMMED AND REMOTE SYSTEMS CORP.			
MATERIAL	ORIG DATE 4-11-77	T.V. & LIGHTING UNIT	NEXT ASSY.
	DR MWL		PROJECT NO. 5004
HEAT TREATMENT / FINISH			SHEET OF / REV.
		SCALE NOTED	DWG. NO P-21708-D

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15.0 VENTILATION AND AIR MONITORING SYSTEM

The Prototype Retrieval System conceptual design includes two separate air handling systems, one for the areas which connect with the waste tank, and one for personnel areas.

A basic requirement for the air handling system which connects with the waste tank is that it must minimize the amount of air-borne contamination which is released to the environment.

This is accomplished by sealing all areas in the System where exposed radioactive material is handled and using air locks on passage ways to such areas. By maintaining them at a slight negative (relative to ambient atmospheric) pressure all air flow will be into the areas. A ventilation unit which consists of an electrically powered blower, filter banks, valves, air heater to prevent freezing of condensate, and instrumentation mounted on a portable base is located over a riser in the waste tank. Ventilation units comparable to what will be required are in use at the Hanford Reservation. The ventilation unit draws air from the waste tank which is connected to the waste retriever by the shielded air seals around the 42-inch diameter risers through which the mining boom and the material elevator operate. Thus, all air flow will be into the shielded areas of the waste retriever, then on through the waste tank to the air handling unit. A HEPA filter bank and radiation detection equipment assure that effluent air is within tolerable radiation limits. Detection equipment to monitor tank pressure, air flow rate, air temperature and hydrogen content is included.

The ventilation unit will operate continuously during operation of the Prototype Retrieval System. A standby diesel generator will start automatically to continue operation of the unit in case of an electric power failure. Means are provided for replacing and disposing of used filters. The ventilation unit has two banks of air filters in a parallel flow arrangement so that air can be diverted to one side or the other when replacing filters during operation of the System.

Electric air heaters are provided for air used in drying components after they have been washed within the waste retriever. This air will be drawn from the outside, heated and discharged through the air handling unit.

Separate ventilation systems are used for the control center trailer and personnel areas of the Prototype Retrieval System. These areas will be heated and air conditioned as required for personnel comfort.

16.0 SPECIAL UTILITIES SYSTEMS

The Prototype Retrieval System incorporates wash-down and drying provisions for waste containers, the mining boom, boom tools and material elevator.

Each of the four cleaning stations will utilize warm water for washing and warm air for drying.

Heating of the water and air, and drying of the air will be accomplished by electrically supplied units in the System.

The water and air systems will include the required piping, ducting, valves and controls. The wash water system will include a 100-gallon holding capacity for used, contaminated water. Because the holding tank(s) will be an area of contaminate concentration, the holding capacity can be obtained by using two 55-gallon drums, located in the shielded filling room of the Prototype System. When the drums accumulate a layer of insoluable sludge, they will be disconnected remotely, placed in shipcons and delivered to the processing plant for disposal and replaced by clean drums. This procedure would be followed in cleaning up the Prototype System prior to movement between waste tanks.

The quantities of water and air used in the System require special consideration.

Water used with the System cannot be discharged into the waste tank. Because it is contaminated, the conceptual design disposes of wash water by using it to flush out material from the elevator into shipping containers. Thus, the small quantity of wash water used is shipped to the processing plant along with the waste material.

Wash-down water is obtained from a fresh water supply at the site. The estimated water usage and inventory is as follows:

- Shipcon washing; 10 gallons (1.337 cu ft.) per shipcon wash.
- Tool washing; 20 gallons (2.674 cu. ft.) per tool wash. The maximum average usage is estimated to be one tool wash per 8-hour shift.
- Mining boom washing; 50 gallons (6.685 cu. ft.) per boom wash. The maximum average usage is estimated to be one boom wash every ten 8-hour shifts.
- Material elevator washing; same as for mining boom.

The normal rate of filled shipcon delivery from the Prototype Retrieval System is one each 72 minutes or 6.67 shipments per 8-hour shift. Each shipcon has a volume of 96 cubic feet.

Because the average amount of water used must be equal to the average amount shipped, it is important to know the volume of water shipped with each container. This volume is determined as follows:

Volume of water shipped with each shipcon:

- shipcon washing	1.337 cu. ft.
- tool washing	.401 cu. ft.
(2.674 cu. ft. per 6.67 shipments)	
- boom and elevator washing	.200 cu. ft.
(6.685 cu. ft. per 66.7 shipments)	
Total per shipcon	1.938 cu. ft.

This represents 1.938/96 = 2.0% of the volume shipped

The rate of water usage is:

$$\frac{1.938}{72}(60) = 1.615 \text{ cu. ft./hr.} = 12.08 \text{ gal/hr}$$

The above rates are believed to be satisfactory.

A 100-gallon (13.37 cu. ft.) wash water storage capacity is provided in the System. This represents a standby capacity of:

- 10 shipcon washings
- 5 tool washings
- 2 mining boom washings
- 8.3 hours average consumption with no water shipment

Should the need for additional water usage occur such as for major maintenance of equipment, or cleaning the System in preparation for moving it between tanks, the amount shipped with each shipcon could be increased, or a large amount handled by using one shipcon for water shipment only.

Warm air used for drying washed shipcons, and other items, as well as for heating personnel areas of the waste retriever must be clean, filtered air drawn from outside. Because the interior of the waste retriever is maintained at a slight negative pressure, the drying air will add to the required capacity of the main air handling system. Although the volume of air so required has not been calculated, it is believed that it will not impose a large additional burden on the main air handling system.

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17.0 INSTRUMENTATION

Instrumentation as required to operate the Prototype Retrieval System in a safe and efficient manner is included conceptually in the design.

The required instrumentation includes:

a. Radiation Measuring Equipment
   This will be installed at appropriate locations in the System to monitor radiation levels. These locations include:

   - Tool Wash Station; to be certain boom tools are clean enough for contact maintenance or to be moved to a tool storage rack.
   - Maintenance Room; to assure that radiation levels remain low enough for maintenance work and to check personnel on leaving the area.
   - Mining Boom Room; to monitor that radiation levels stay at an acceptable level.
   - Container Filling Room; to monitor that radiation levels stay at an acceptable level, since this is the area which will have the highest radiation levels, several sensors will be used.
   - Container Wash Station; to assure that shipping containers are clean enough to move out of the shielded wash station.
   - Shipping Room; to monitor that radiation levels remain at a safe level.
   - Ventilation Unit; to assure that discharged air is at acceptably low radiation levels, the out let of the ventilation unit will be monitored.

b. Temperature Measuring Equipment

Temperature sensors will be included on the television camera supports to monitor in-tank temperatures.

Sensors will be included in each area of the Prototype Retrieval System to monitor that suitable temperatures are maintained.

c. Pressure Measuring Equipment
The interior of the Prototype Retrieval System and the waste tank will be maintained at a pressure slightly below ambient to assure that there is no discharge of air except through the ventilation unit and also to prevent the tank pressure from dropping below the minimum allowable vacuum of three inches of water. Pressure sensors will be included in all of the air-controlled areas of the System.

d. Hydrogen Concentration Measuring Equipment
Hydrogen measuring equipment will be incorporated into the air-handling unit to assure that hydrogen levels stay below acceptable limits. There is some indication that water content of the waste material is low enough that hydrogen generation will be negligible.

e. Waste Material Weighing
A weighing system incorporated into the elevator will give a rough indication of the amount of waste material shipped.

f. Ventilation Unit and Standby Generator
Instruments indicating the status and operation of the ventilation unit, and the standby diesel generator will be included.

g. Water System

A water level gage will be incorporated in the water holding tank to control the amount of water on board the waste retriever.

h. Other Operating Instrumentation

Other instrumentation required for monitoring and operating the Prototype Retrieval System, based on more detailed design of the System will be included.

Instrumentation readouts, recorders and alarms will be housed in the control center.

A detailed analysis of the operating requirements and the instrumentation system will clarify the processing of the outputs into categories of:

- indicate
- record
- control
- alarm

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18.0 TRANSPORTERS (Ref: Figure 18-1,18-2,18-3, 18-4)

The prototype waste retriever is moved from tank to tank as a complete unit. Mobility is provided by three transporters, one at each extremity of the tee-shaped structure.(Figure 18-1). These transporters are track type vehicles previously developed for applications where large, heavy structures are to be moved over ground without the advantage of prepared pathways such as rails or concrete strips.

Three graded, leveled areas at the transporter locations at each tank are provided to level the prototype waste retriever.

The transporters are self-powered and each has an operator or driver. The three drivers and two or three directors or observers on foot are trained to work together as a team to perform the moving operation. Close communication is required. A very slow rate of movement is used, i.e., approximately three feet per minute.

Each transporter is equipped with a bolster assembly through which the transporter is attached to the structure. The bolster assemblies provide the necessary flexibility between transporter and structure so that unpredictable stresses are not imposed on the structure. Referring to Figures 18-1, 18-2, 18-3, and 18-4, the bolsters on the three transporters provide the following degrees of freedom:

Transporter A-	Rotation about the X,Y, and Z axes.
Transporter B-	Rotation about the X,Y, and Z axes and, possibly, lateral translation in the Y direction.
Transporter C-	Rotation about the X,Y, and Z axes, and lateral translation in the X and Y directions.

As transporters move the structure from tank to tank, transporters A and B are used for basic steering control by driving them so as to cause sensors or locators on the structure to follow along a guide wire. This guide wire has been properly placed relative to the tank risers beforehand to insure correct location in the "X" direction.

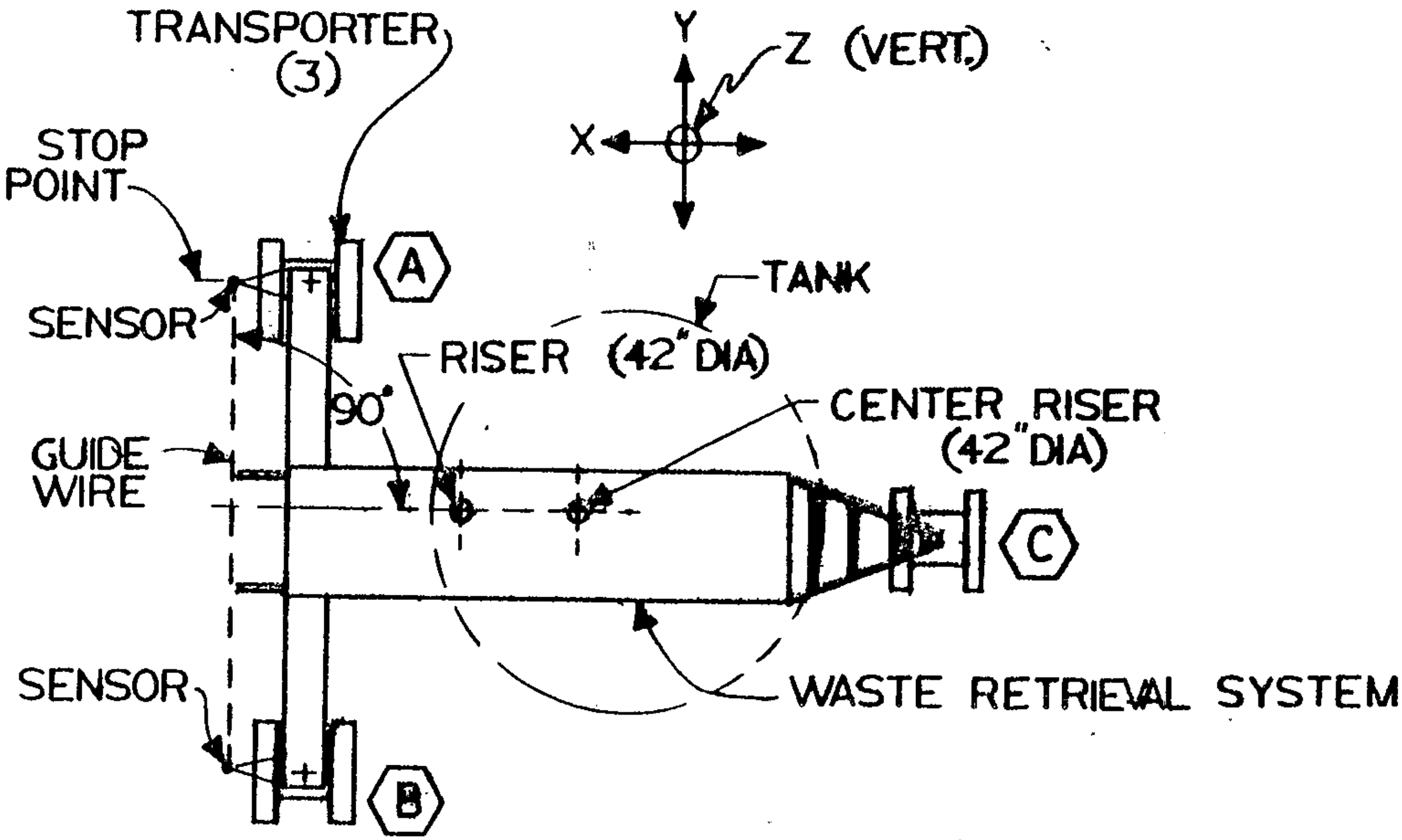
A stop point on the guide wire, controls positioning in the "Y" direction.

The driver of the C transporter follows the movement of the structure resulting from maneuvering of the other two transporters. The bolster device supporting the load on the C transporter has five degrees of freedom to allow for relative motion of the C transporter under the structure. The C driver must maneuver to keep the movement of the bolster components within the limits of travel. Indicating devices or sensors are incorporated in the bolster assembly to assist the C driver and communication with the other two drivers is also necessary. The bolster on the C transporter also compensates for minor tilting of the transporter under the structure because of uneven terrain.

The bolsters on the A & B transporters also have rotational freedom about the X & Y axes to compensate for uneven terrain.

In the case of transporters A & B, it is expected that fore and aft forces in the "Y" direction, transmitted through the structure, will keep the two transporters moving together. (This point needs to be investigated and if actual experience shows that excessive fore and aft forces can develop, it will be necessary to incorporate provisions for Y translation in the B transporter).

All three transporters have a large azimuth bearing under the



TRANSPORTER ARRANGEMENT

FIGURE 18-1

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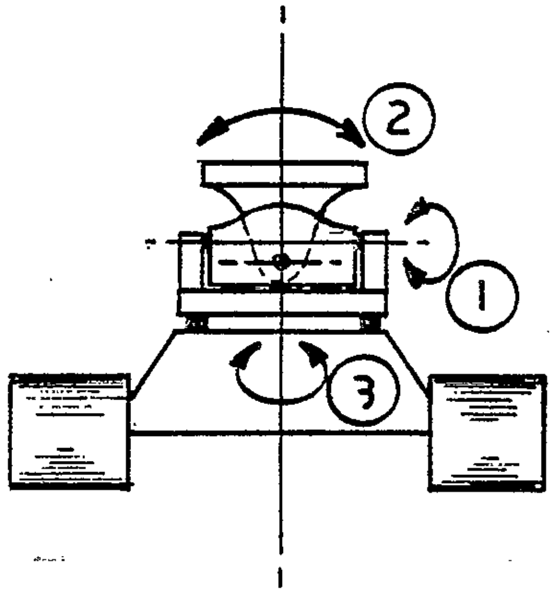
① X ROTATION

② Y ROTATION

③ Z ROTATION



TRANSPORTER "A"

FIGURE 18-2

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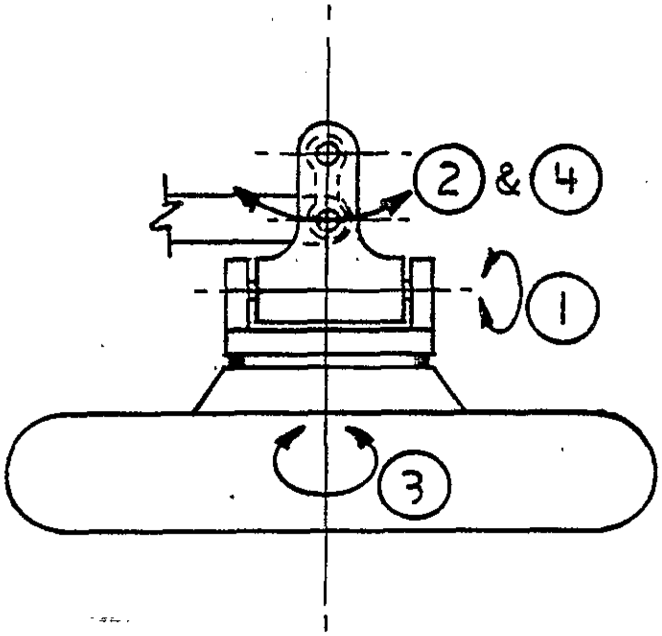
1	Y	ROTATION	3	Z	ROTATION
2	Y	TRANSLATION	4	X	ROTATION



TRANSPORTER "B"

FIGURE 18-3

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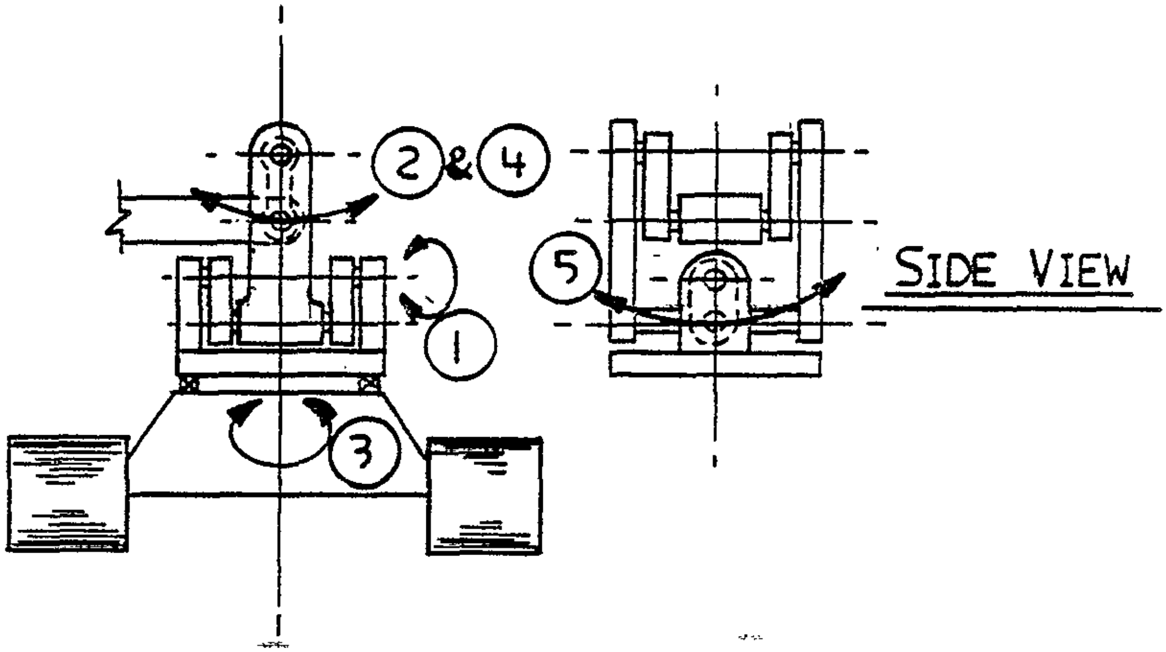
1 X ROTATION

2 Y ROTATION

3 Z ROTATION

4 X TRANSLATION

5 Y TRANSLATION



TRANSPORTER "C"

FIGURE 18-4

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bolster to permit rotation about the vertical axes.

General approximate specifications for the transporter are as follows:

* Vertical load capacity, moving	271,000 lb.
* Vertical load capacity, parked	301,000 lb.
* Braking power, parked	32,000 lb.
Travel speed	Up to 1.5 mph
Grade capability	5 per cent
Weight	80,000 lb.
Length of track	22 feet
Width of track	48 in.
Overall width	16 feet
Height to top of bolster	102 in.
Powerplant	Diesel engine

* See Section 19.3, Loading Imposed on Transporters.

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19.0 SYSTEM STRUCTURAL AND WEIGHT ANALYSES

19.1 STRUCTURAL ANALYSIS (Ref: Figure 6-1)

A partial structural analysis of the main frame was performed as a means of investigating the feasibility of designing a suitable structure using the box-truss concept shown in Figure 6-1. The SAGS (Static Analysis of General Structures, Structural Dynamics Research Corporation) computer program was used to make a planar frame analysis of one side of the main frame. The results are presented in Appendix D, and the data shows that a structure based on the box-truss frame concept is a feasible design approach.

Two loading conditions were analyzed: dead loading (No. 1), and wind and dead loading (No. 2). For the first case the maximum deflection was 1.063 inches, occurring at joint No. 12. For the second case the deflection increased to 1.139 inches, occurring at joint No. 13. (Refer to Appendix D, Plot No. 1, for joint designation). The stresses in various spans are considered to be of acceptably low magnitudes in view of the investigative nature of the analysis. During actual design of the frame structure it will be necessary to assure that combined stresses in all members are within allowable values.

The dead loading used in the analysis was derived from the weight of the frame structure itself plus the weights of all of the items which the frame must support. Weight estimates for these items are listed in Appendix C. The roof loading included in Table 19-1 is based on a live load of 20 p.s.f. taken from the Uniform Building Code, 1976 Edition, Table No. 23-C, for a flat roof. Since roof panels are included as a separate item, the 20 p.s.f. could be considered a snow load in lieu of a specified snow load. The mining boom tower and the material elevator tower are not centered in the structure.

Consequently, the side frame which bears the larger load was used as the case for analysis. All loads, with the exception of the weight of the frame itself, were applied to the various joints as concentrated loads in a ratio depending upon location of the load relative to the joints.

For the second loading case, the wind loading, which is added to the dead load is the vertical force in the frame produced by the moment at the base of the mining boom tower or the material elevator tower which results from wind forces on the towers. The following wind pressure data taken from the Uniform Building Code, 1976 Edition, Table No. 23-F and Figure No. 4, was used.

Height Zone	Wind Pressure
Less than 30 feet	15 p.s.f.
30 to 49 feet	20 p.s.f.
50 to 99 feet	25 p.s.f.

The structural steel members used for the various spans, as identified by section code numbers, (See Appendix D) are as follows:

Code No. 1	W 24 x 120
Code No. 2	W 24 x 84
Code No. 3	Round bar, 2" diameter
Code No. 4	TS 8 x 8 x .312
Code No. 5	TS 8 x 6 x .25
Code No. 6	C 12 x 25

(Note: Properties for the above sections were taken from "Manual of Steel Construction" AISC, 7th Edition, 1973).

19.2 WEIGHT ANALYSIS

Estimated weights for the various components of the waste retriever are tabulated in Appendix C and Section 18.0. These weights are summarized in Table 19-1 for two cases. First, for the case when the Waste Retrieval System is being moved from tank to tank it is assumed that all waste material as well as all shipping and sealing containers are removed prior to the moving operation. Under these circumstances the estimated weight, including transporters, is 892,090 pounds.

When the Retrieval System is in operation, the weight of waste material being handled along with the shipping and sealing containers must be included. This brings the total estimated weight to 994,100 pounds.

If a roof (snow) loading of 37,920 pounds is added, the total load increases to 1,032,020 pounds.

9 2 1 2 3 0 1 3 2 5 7

TABLE 19-1 SUMMARY OF ESTIMATED WEIGHT OF WASTE RETRIEVER

A.	Main Structure W/O Shielding		322,570
B.	Shielding		169,510
C.	Installed Equipment W/O Shipping Containers		152,510
D.	Instrumentation and Controls and Electrical		3,500
E.	Small Tools and Supplies and Spare Parts		4,000
F.	Transporters 3 at 80,000 lbs.		240,000
Total weight when moving from tank to tank			892,090 Lbs.
G.	24 $Ft.^3$ Waste In Elevator Bucket	2,570	
H.	Two Full Shipcons (Shielded)	54,420	
I.	One Empty Shipcon (Shielded)	17,030	
J.	One Empty Sealcon	5,480	
K.	One Empty Set, Sealcon + Shipcon	22,510	
			102,010
	Operating weight without roof load		994,100 Lbs.
L.	Roof (Snow) Load		37,920
	Operating weight with roof load		1,032,020 Lbs.

19.3 LOADING IMPOSED ON TRANSPORTERS

The waste retriever is supported at three points on track-type transporters as described in Section 18.0. The loading imposed on the transporters when the system is in operation will be greater than when the system is being moved because all waste material and shipping and sealing containers will be removed before the system is moved. Forces resulting from roof (snow) load, wind pressure, and earthquake are considered in addition to the system weight in analyzing the total loading on the transporters.

An analysis of the loading imposed on the transporters is presented in Appendix E. Five loading cases are considered as follows:

Case I	Operating; without wind and snow loading
Case II	Operating; with wind loading
Case III	Operating; with wind plus snow loading
Case IV	Operating; with earthquake
Case V	Moving from tank to tank

In all cases the outboard transporters are required to support greater loads than the one at the end of the main structure. However, it is recommended that the same size of transporter be used in all three locations. Consequently, the load-bearing capability required of the transporter will be dictated by the largest load on an outboard unit. This occurs for Case IV where the transporters are static. For Case IV the estimated vertical load on an outboard transporter is 300,890 pounds. The horizontal seismic load shared by the three units is 94,260 pounds.

Case V is of interest because the power required to drive the transporter will depend upon the loading occurring when moving. For this case the vertical load on an outboard unit is 234,100 pounds. The horizontal load when negotiating a 5 per cent grade is 32,600 pounds.

Cases I, II, and III are indicative of all loads imposed under normal operating conditions. The greatest vertical load occurs for Case III and amounts to 289,980 pounds on an outboard transporter. The horizontal wind load shared by the three units is 42,105 pounds. This latter load determines the brake holding power required of the transporter.

9 2 1 2 5 0 1 0 2 5 0

19.4 SOIL LOADING AT SUPPORT POINTS (Ref: Figure 19-1)

Because of the relatively large load which is to be supported without the use of specially prepared concrete roadways or footings, it is of interest to examine the bearing capacity of soil as it relates to the concept of supporting the waste retriever on three mobile transporters. "Mark's Handbook for Mechanical Engineers:, 7th Edition, Page 12-30, Table 6, lists the following for various soil types:

Nature of Soil	Safe Bearing Capacity* Tons/Sq. Foot	Lbs/Sq. In.**
Compact sand and gravel, requiring pick for removal	4-6	55.6-83.3
Hard clay, requiring pick for removal	4-5	55.6-69.4
Gravel, coarse sand, in natural thick beds	4-5	55.6-69.4
Loose, medium, and coarse sand; fine compact sand	1.5-4	20.8-55.6
Medium clay, stiff but capable of being spaded	2-4	27.8-55.6
Fine loose sand	1-2	13.9-27.8
Soft clay	1	13.9

* Safe Bearing Capacity as Related to Support of Permanent Structures.

** (Tons/Sq.Ft.) x 13.89 = Lbs/Sq.In.

Based on visual examination of the soil at the Hanford Reservation tank farms, and a study of the above table, one would conclude that the tank farm soil has a safe bearing capacity of at least 1.5 tons/sq. ft. or 20.8 lbs/sq. in.

In the previous section, the loading imposed on the transporters was discussed. The weight of the transporter itself must be added to the vertical load, for the loading case of interest, to obtain the corresponding load bearing on the soil. An estimated transporter weight of 80,000 lbs. and track/soil contact area of 150 sq. ft. was used to obtain the unit soil bearing pressures for the various cases as tabulated below.

	Loading Case	Vertical Loads. Lbs.	Soil Bearing Pressure Tons/Sq.Ft.	Lbs/Sq. In.
I	Operating; without wind and snow loading	270,720	1.17	16.24
II	Operating; with wind loading	277,385	1.19	16.55
III	Operating; with wind plus snow loading	289,980	1.23	17.13
IV	Operating; with earthquake	300,890	1.27	17.64
V	Moving from tank to tank	234,100	1.05	14.54

Thus, it appears that expected soil bearing pressures can be supported safely by the soil at the tank farms on the Hanford Reservation.

A cursory examination was also made of the load being transmitted through the soil to the wall and dome of the tank. The analysis was performed for PaR by ESI of Minneapolis, Minnesota.

The vertical and radial stresses at any point in the soil below a concentrated load were obtained from the following Boussinesq Equations.

$$\sigma_z = \frac{Q}{2\pi} \frac{3z^3}{(r^2 + z^2)^{5/2}}$$

$$\sigma_r = \frac{Q}{2\pi} \left(\frac{3r^2 z}{(r^2 + z^2)^{5/2}} - \frac{1-2\mu}{r^2 + z^2 + z\sqrt{r^2 + z^2}} \right)$$

where Q = Concentrated load
μ = Poisson's ratio (μ = 0.3 was used)
Z = Vertical distance to point of interest
r = Radial distance to point of interest

Figure 19-1 shows the dimensions to the points for which the stresses were calculated using a concentrated load of Q = 400 ksf. (Note that the actual estimated load of approximately 381,000 lbs. is distributed over the area covered by the tracks of the transporter). A tank wall thickness of 18 inches was assumed. The stresses which were obtained at the above points are tabulated below:

Point	r	Z	σ_r, ksf	σ_z, ksf
A	51	6	-.0003	.0001
B	31.5	9	.0266	.0037
C	12	21	.0464	.2137
D	12	37	.0028	.1086
E	12	51	-.0011	.0642

The stresses are a maximum at point C, the intersection of the wall and the dome. However, the combined stress of 260 p.s.f. is low compared to the unit loading of the overburden of approximately 2,100 lbs/sq. ft. at point C.

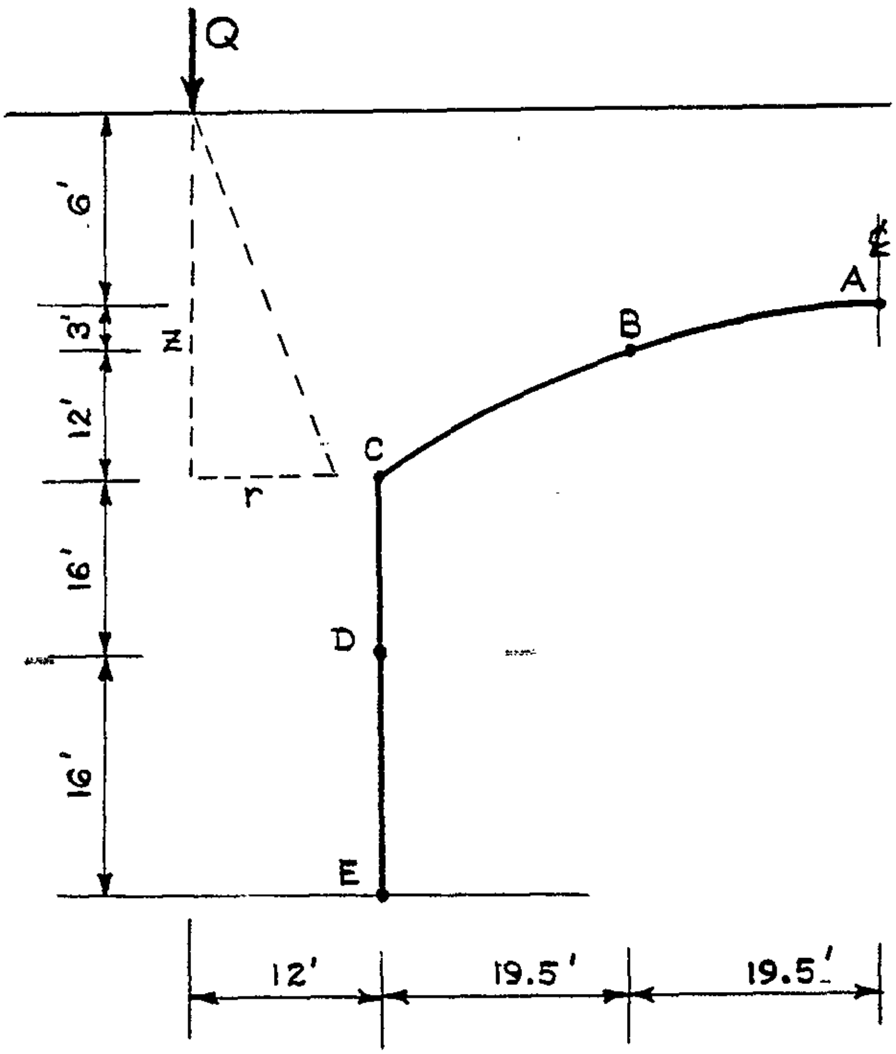

Figure 19-1
Location of Points at Tank Surface used in Soil Stress Calculations

20.0 HYDRAULIC SYSTEM (Ref: Figure 20-1)

The main hydraulic supply system, as shown schematically in Figure 20-1, consists of a hydraulic system for the mining boom and one for the material handling elevator. A third hydraulic supply serves as a back-up unit for both systems. These units are mounted in the power center room, for easy access.

Fire resistant fluids will be used throughout the entire system. Of the three types of fire resistant hydraulic fluids available, a straight phosphate ester fluid was selected because it has definite advantages over the water glycol and water-in-oil emulsion type fluids.

Monsanto Pydraul 29E-LT straight phosphate ester fluid provides excellent stability and lubricity properties, ease of maintenance and freedom from corrosive action and foam. It passes all of the important ignition tests for fire resistance and contains no water to evaporate. The Pydraul fluids do not wear out and can be used at high working pressures.

The water/glycol and water-in-oil emulsion fluids were not selected for the following reasons:

- The water/glycol fluid is only a fair lubricant, can only operate at moderate pressures, requires a high fluid maintenance and has only fair corrosion resistance.

- Water-in-oil emulsion, like water/glycol, has only fair lubricity, poor stability (loss of water), becomes a non-neutonion fluid, must operate at moderate pressures, has a high fluid maintenance and only fair corrosion resistance.

20.1 MINING BOOM HYDRAULICS

The main hydraulic system for the mining boom consists of a hydraulic power unit, servo operated directional control valves, miscellaneous flow control valves, cylinders, motors and a hydraulic hose handling system.

The hydraulic power unit is rated at approximately 25 G.P.M at 2000 PSI. The hydraulic power unit will be designed to give a good accessibility of its components for ease of maintenance. In the event that maintenance is required while retrieval operations are underway, the backup hydraulic power unit can take over and supply power until the main unit is back in service.

Servo operated directional control valves are used for actuating and providing variable speed control for the motions. The valve mounting is designed with mechanical, hydraulic and electrical quick disconnects for ease of valve removal and replacement.

In the event of a hydraulic power supply or valve failure when the mining boom is extended inside the tank, provisions will be incorporated into the hydraulic system enabling the operator to remove the mining boom from the tank. This is accomplished with by-pass valves that will allow the boom to sag and straighten out by gravity when it is removed from the tank.

Heavy duty hydraulic cylinders are used for actuating the boom members. Motion control and lock valves are provided at each actuator which can lock the load in any position without drift and which provide static overload relief protection. The main boom rotate is driven by a hydraulic motor through a mechanical gear reducer. Overload relief protection is provided.

20.2 MINING BOOM TOOLS HYDRAULICS

The mining boom tools are equipped with hydraulic and electrical quick disconnects to interface with the hydraulic valve manifold on the mining boom tool adapter. The connections consist of hydraulic supply and return lines, electrical connect, air connect and a spare connect.

Servo operated directional control valves are used to provide variable speed control to the motions.

Like the mining boom, motion control and lock valves are provided for critical load bearing hydraulic actuators.

20.3 MATERIAL ELEVATOR HYDRAULICS

The Material Elevator hydraulic system consists of a hydraulic power unit, solenoid operated directional control valves, hydraulic actuators and a hose handling system.

The hydraulic actuators include a rotary type vane actuator for rotating the bucket support yoke, a hydraulic cylinder to swing the bucket 30 degrees to the dump position, and two bucket unloading hydraulic cylinders to operate the door on the bottom of the bucket.

The hydraulic power unit is rated at approximately 15 G.P.M. at 2000 PSI. The design of the power unit is similar to the hydraulic power unit used for the mining boom.

As in the case for the mining boom, the stand-by hydraulic power unit can take over to supply power if the main unit is shut down for maintenance.

Solenoid operated directional control valves are used to actuate and control the motions.

Valve mounting is designed with mechanical, hydraulic and electrical quick disconnects for ease of replacement.

20.4 MISCELLANEOUS HYDRAULIC DRIVE SYSTEMS

Smaller independent hydraulic systems will be used for supplying power for various drives on other items of equipment such as the shipping and receiving turntable, tool change machine, heavy shielding doors, etc. These systems will incorporate the same safety and control features as previously discussed for the mining boom and the material handling elevator.

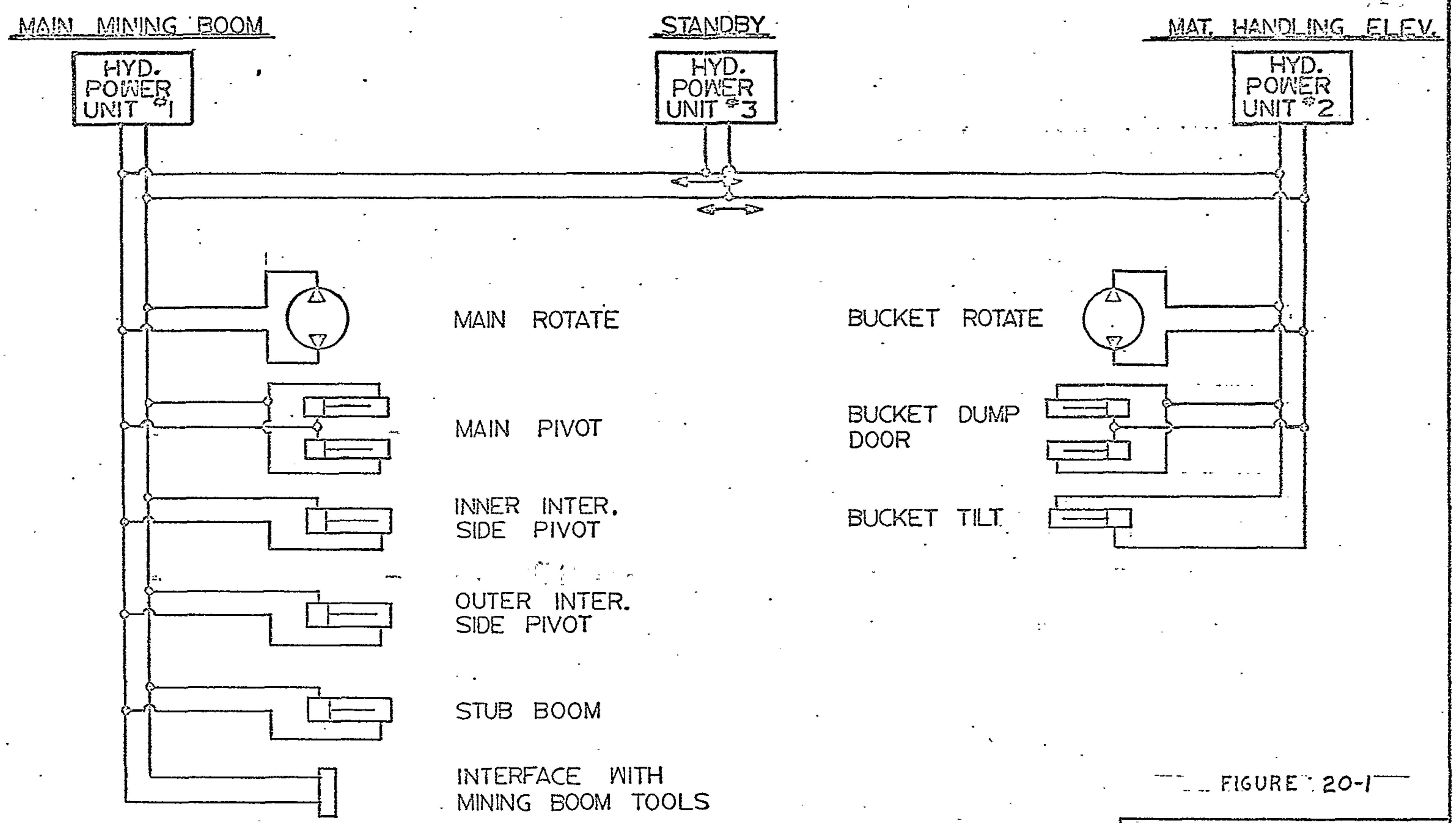

FIGURE 20-1

HYDRAULIC SCHEMATIC	
P-21691-C	SHT. 1 OF 1

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21.0 CONTROL SYSTEM

The control system for the Waste Retrieval System consists of an "on-board" system and a remote system. Both systems utilize a minicomputer system. The minicomputers are used to implement the interlocks for the various machines, generate a graphic display, and implement the mining boom obstacle avoidance system.

The on-board, or local system, is housed within the waste retriever structure. The remote system is housed within a control center trailer.

21.1 REMOTE CONTROL SYSTEM (Ref: Figure 21-1)

A typical operator's control console is shown in Figure 21-1. This console mounts the TV monitors, graphic display, and control panels for the following:

1. 20-Ton Crane
2. Turntable
3. Lid Handling Machine
4. Material Elevator
5. Mining Boom
6. Mining Tools
7. Tool Change Machine
8. 2-Ton Crane
9. Miscellaneous Controls
10. Model 3000 Manipulator
11. TV Controls

The control design (and control panel arrangement) allows one or two operators to easily operate and monitor all of the controls.

These controls are discussed in the following sections.

The remote system minicomputer acts as a high-speed communications link with the minicomputer in the on-board control system. Control signals generated within the control center are transmitted via a high-speed serial data loop to the on-board minicomputer. Similarily, signals generated by the on-board system are transmitted to the remote system minicomputer via the same data loop.

21.1.1 REMOTE CONTROL SYSTEM CONTROL PANELS

(Ref: Figures 21-2 through 21-16)

20- TON CRANE CONTROLS

The controls for the 20-ton crane are shown on Figure 21-2. The control panel mounts the necessary control pushbuttons, selector switches, indicators, position readouts, and fingerswitches to control the crane.

The fingerswitches are spring-centered to the "off" position. Deflection of the fingerswitch handle causes a voltage proportional to the amount of deflection to be generated at the wiper of a potentiometer. This voltage is used to command the DC motor driver and generates a stepless rate control for that motion.

Each motion has its own position readout system. A readout system is comprised of an absolute-type position encoder which drives a PaR Model 1200 Absolute Position Readout (see Appendix F). The Model 1200 features a set of thumbwheel switches to electrically zero the display. Miniature remote displays are mounted on the control panel to display the actual position.

Bridge and trolley travel are stopped in both directions by limit switches with an indicator showing when either bridge travel limit is reached. A bypass switch allows the operator to override the normal bridge travel limits to move through the crane passageway doors or over the truck. A selector switch controls the passageway door.

The hoist motion is stopped at its extreme travel limits by an up limit switch and down limit switch. Indicators are provided to show the limit conditions.

The hoist cable load is measured and displayed via an electronic load cell system. Hoist lowering is stopped if an underload condition occurs as indicated by the "Underload" indicator. A lighted push-pull switch provides the capability to continue lowering when necessary.

The bridge and trolley can be operated in either a manual control mode (fingerswitch control) or an automatic mode, as selected by the Control Manual/Auto Selector. In the "auto" control mode, the desired bridge and trolley position is selected by the "Destination" selector switch (Sealcon #1, Sealcon #2, or Turntable location). Momentarily depressing the Auto Sequence "start" pushbutton initiates the bridge and trolley motion. The auto sequence stops when the bridge and trolley reach their selected destination or when the Auto Sequence "Stop" pushbutton is momentarily depressed.

TURNTABLE CONTROLS

The controls for the turntable and its airlocks are shown on Figure 21-2. The controls include the necessary pushbuttons, selector switches, and indicators to provide manual control and an auto sequence.

With the Control Manual/Auto selector switch in the "Manual" position, all of the control operators are effective. Selector switches command the various doors of the two air locks to the desired positions. Indicators provide the door status for each door.

Momentarily depressing the Turntable Rotate lighted pushbutton causes the turntable to rotate sixty degrees in the clockwise direction and stop. Rotate motion can be stopped at any time by momentarily depressing the Turntable Stop pushbutton.

A push-pull lighted pushbutton is provided to turn on the washing system to wash down the shipcon inside the wash station air lock.

With the Control Manual/Auto selector switch in the "Auto" position, all of the manual control operators are ineffective. An automatic sequence is initiated by momentarily depressing the Auto Sequence Start pushbutton. The sequence of motions occur as follows:

1. The Entrance Air Lock Entrance Door opens and the Wash Station Airlock Exit Door opens.
2. The Turntable rotates 60 degrees clockwise and stops.
3. The Entrance Air Lock Entrance Door closes and the Wash Station Air Lock Exit Door closes.
4. The Entrance Air Lock Exit Door opens and the Wash Station Air Lock Entrance Door opens.
5. The Turntable rotates 60 degrees clockwise and stops.
6. The Entrance Air Lock Exit Door closes and the Wash Station Air Lock Entrance Door closes.
7. The washing system washes the shipcon for a fixed period of time. The washing and drying cycles are controlled by an adjustable timer.

The Auto Sequence Stop pushbutton, when momentarily depressed, stops the auto sequence.

LID HANDLING MACHINE CONTROLS

The lid handling machine controls are shown on Figure 21-3. Pushbuttons, selector switches, and indicators provide complete manual control and an automatic sequence.

With the Control Manual/Auto selector switch in the "Manual" position, all selector switches are effective to command the various motions as shown. Indicator lights provide the status of the various motions.

With the Control Manual/Auto in the "Auto" position, an automatic sequence for lid removal/attachment is initiated by momentarily depressing the Auto Sequence Start pushbutton. A lid removal sequence is as follows:

1. The tool rotates to its CCW limit
2. The tool lowers to its down limit
3. The lid grapple closes
4. The lid lock disengages
5. The tool raises to its up limit
6. The tool rotates to its CW limit

A lid attachment sequence is as follows:

1. The tool rotates to its CCW limit
2. The tool lowers to its down limit
3. The lid lock engages
4. The lid grapple opens
5. The tool raises to its up limit
6. The tool rotates to its CW limit

The automatic sequence is stopped by momentarily depressing the Auto Sequence Stop pushbutton.

MATERIAL ELEVATOR CONTROLS

The control panel for the material elevator is shown on Figure 21-3. Pushbuttons, selector switches, indicators, and readouts provide complete manual control and an automatic sequence.

The hoist is manually controlled by momentarily depressing the Raise or Lower pushbutton. Hoist raise motion stops when the up limit is reached (corresponding to the dumping elevation) or the Hoist Stop pushbutton is momentarily depressed. Hoist lowering normally is stopped by momentarily depressing the hoist Stop pushbutton. A slack cable condition will also stop hoist lowering. Indicators provide Cable Slack and Up Limit indication.

Hoist elevation is obtained via an absolute position encoder, a PaR Model 1200 positionn readout (See Appendix F), and a remote display.

The hoist cable load is sensed by a strain gage load cell, signal conditioned, and displayed.

Selector switches provide manual control of the bucket tilt, rotate, and bottom cover positions. Indicators are provided for the status of these motions.

Indicators are provided to show that a shipping container is in position on the turntable and that its lid has been removed.

An automatic sequence for unloading a filled elevator bucket is obtained by momentarily depressing the Auto Sequence Start pushbutton with the Control Manual/Auto selector switch in the Auto position. The sequence is as follows:

1. The hoist raises to the up limit (dumping position)
2. The bucket rotates to its dumping position
3. The bucket tilts
4. The bucket bottom cover opens
5. The cover closes (after a timed period)
6. The bucket tilts to its vertical position
7. The bucket rotates to its normal position
8. The hoist lowers to its previous elevation

The automatic sequence is stopped at any time by momentarily depressing the Auto Sequence Stop pushbutton.

MINING BOOM CONTROLS

The mining boom controls are shown on Figure 21-4. The control panel mounts the necessary fingerswithces, remote readouts, indicators, and pushbuttons to control the mining boom in a manual control mode and several automatic sequences.

The fingerswitches (identical to those described previously) for the mining boom (except the hoist) are used to drive electrohydraulic servovalves and produce variable rate commands. The hoist fingerswitch controls the three phase hoist motor and produces a single speed in the raise and lower directions.

The hoist position is sensed and displayed by an absolute position encoder, a PaR Model 1200 Readout, and a remote display.

Position information for the various motions (except the hoist) is obtained by the use of servo potentiometers mounted on the various pivots. The wiper voltages from the potentiometers are fed into scaling amplifiers. The scaling amplifier outputs drive digital voltmeters. The digital voltmeters drive remote displays and also provide the minicomputer system with BCD position information.

An electronic weighing system measures and displays the cable load continuously. Hoist lowering stops when an underload condition occurs, as indicated by the Hoist Underload indicator.

Hoist raise motion stops when the up limit is reached (Up Limit indicator lighted). An indicator, the Tool Change Elevation indicator, lights when the hoist is at the elevation to change tools on the mining boom.

A lighted push-pull switch, labeled Washing System, is provided to wash down the mining boom when raising the mining boom out of the tank.

Pushbuttons are provided to allow the operator to command the mining boom to move automatically from its digging position to the elevator station or to move from the elevator station to its previous digging position. This automatic control is implemented by the minicomputer system as follows:

Upon command to move to the elevator position, the minicomputer stores all of the boom position coordinates, the hoist coordinate, and the last computed "end-of-boom" coordinate. The minicomputer then commands the hoist to raise or lower until the hoist is at the present elevator position. After the hoist is in its proper elevation, the minicomputer commands the various mining boom motions to move towards their predetermined coordinates. When all mining boom motion stops, the end of the boom is positioned over the elevator bucket.

A similar sequence occurs when the mining boom is commanded to return automatically from the elevator position to the previous mining position.

During all of the automatic sequences described previously, the graphic display will continuously show the location of the last mining location.

TOOL CONTROLS

Each tool has its own control panel mounted on a module which inserts into an opening between the mining boom control panel and the tool change machine control panel. The modules are provided with short handles and fast-acting engage/disengage hardware to facilitate quick and easy removal/insertion.

When a tool is installed on the mining boom, the operator merely removes the previous control module, stores it, and inserts the desired control module.

Listed below are the control modules for the following tools:

- Pipe Cutoff Tool-External
- Impact Hammer
- Object Handling Tool
- Rod and Cable Cutting Tool
- Wall Cleaner
- Clam Bucket
- Backhoe
- Pipe Cutoff Tool-Internal

The control modules for the above tools are shown in Figures 21-5 thru 21-12.

TOOL CHANGE MACHINE CONTROLS

The tool change machine controls are shown on Figure 21-13. All controls for this machine are manual.

Fingerswitches (described previously) provide variable speed control for the various motions. Position information is measured by absolute position encoders and displayed via PaR Model 1200 Readouts and remote displays. Selector switches are used to insert/retract the locking pin and for opening/closing the tool washing area. Indicators provide the status of the pin and the door.

A lighted push-pull pushbutton is used to activate the tool washing system. The washing and drying times are controlled by an adjustable timer.

2-TON CRANE CONTROLS

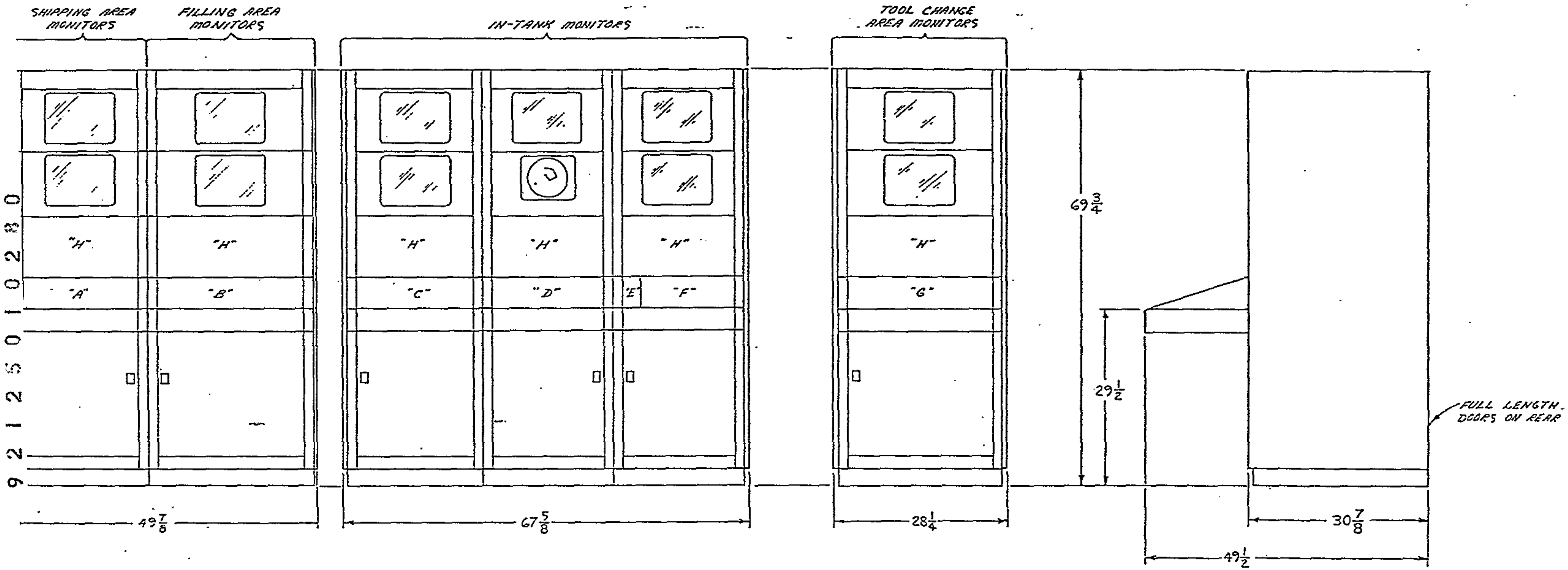
A typical control panel to control the 2-ton crane is shown on Figure 21-14. The crane can be controlled only manually, with fingerswitches generating the required speed commands for the various motions.

The positions of the various motions are sensed by absolute encoders and displayed via PaR Model 1200 readouts and remote displays.

A lighted push-pull pushbutton, labeled Bridge/Trolley Limit Bypass, allows bridge/trolley travel beyond their normal travel limits (indicated by the Bridge/Trolley Limit Indicator).

Cable Slack and Overload indicators provide indication of

A	GENERAL UPDATING	4-13-77	



CONTROL PANEL	DESCRIPTION
A	MODEL 3000 MANIPULATOR
B	20-TON CRANE & TURNTABLE
C	LID REMOVAL TOOL & MATERIAL HANDLING ELEVATOR
D	MINING BOOM
E	TOOL CONTROL
F	TOOL CHANGE MACHINE
G	2-TON CRANE & MISCELLANEOUS
H	TV POSITIONER CONTROLS

FIGURE 21-1

PROGRAMMED AND REMOTE SYSTEMS CORP.			
ORIG. DATE 3-16-77	NAME CONTROL CONSOLE	NEXT ASSY.	
		PROJECT NO. 5004	
		SHEET 1 OF 1	REV.
	SCALE 1/8=1	DWG. NO. P-21601-D	A

REV.	DESCRIPTION	DATE
A	ADDED "LOADOUT DOOR" CONTROLS	4-13-77

-00020

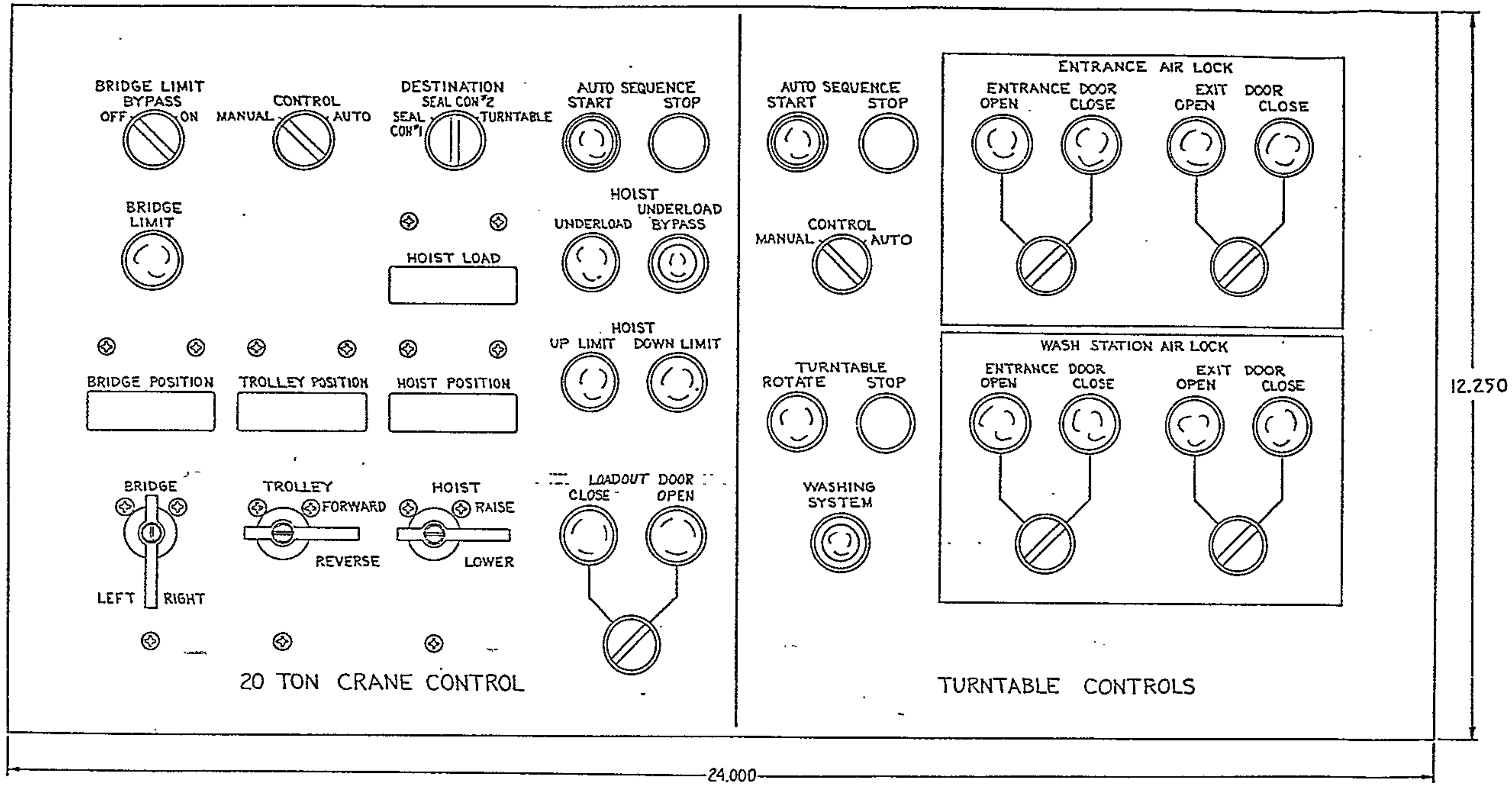


FIGURE 21-2

PROGRAMMED AND REMOTE SYSTEMS CORP.

MATERIAL	
HEAT TREATMENT	FINISH
DATE	3-14-77
NAME	20 TON CRANE & TURNTABLE CONTROL PANEL
PROJECT NO.	5004
SHEET	1 OF 1
SCALE	1=1
DWG. NO.	P-21554-D
REV.	A

92125010281

AHH-C-00020

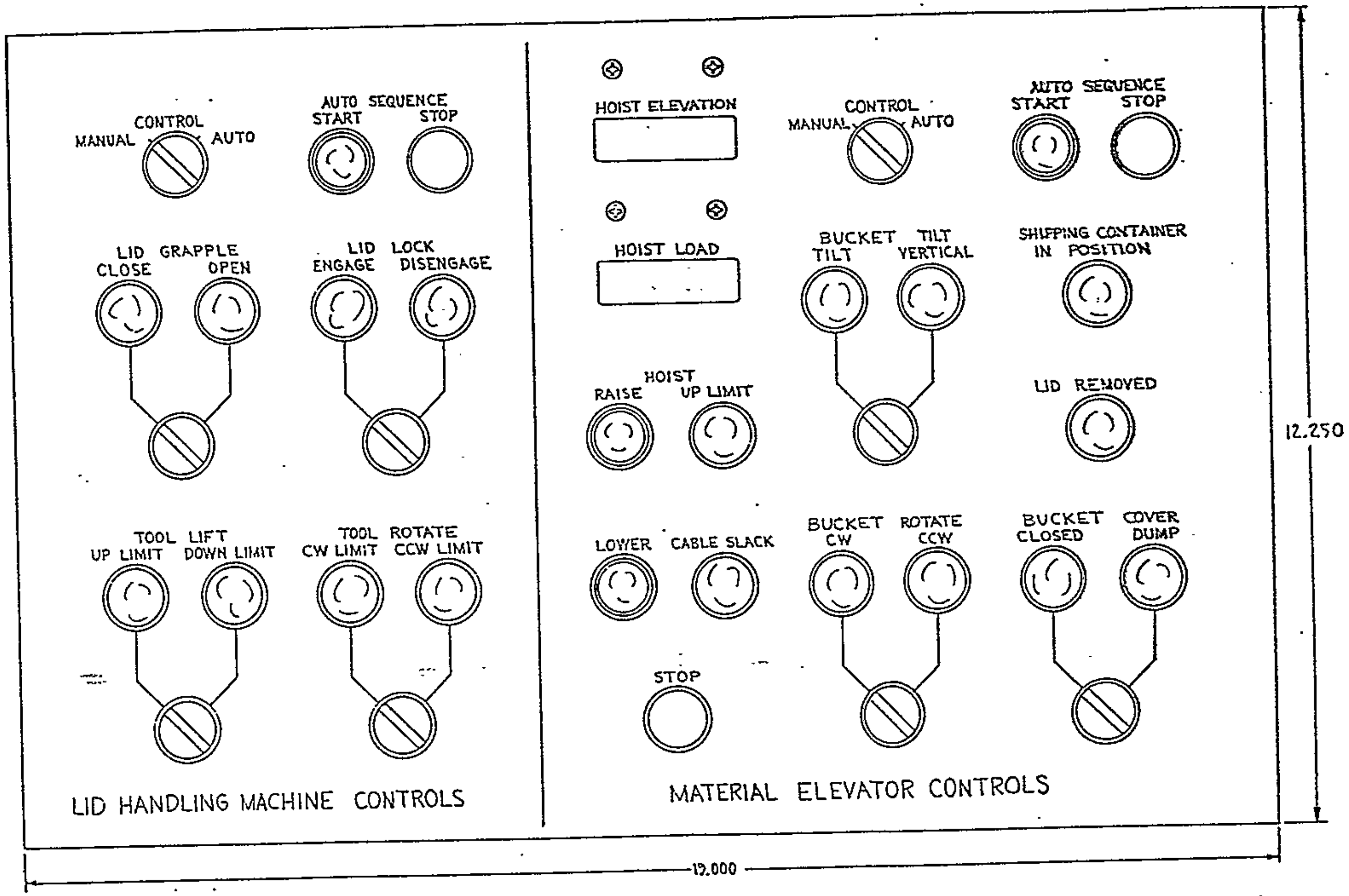


FIGURE 21-3

PROGRAMMED AND REMOTE SYSTEMS CORP.

MATERIAL		ORIG. DATE 3-15-77	NAME LID HANDLING MACHINE & MATERIAL ELEVATOR CONTROL PANEL	NEXT ASSY
		DR		PROJECT NO. 5004
HEAT TREATMENT	FINISH	CHK		SHEET 1 OF 1 REV.
		ENG		DWG. NO. P-21555-D A
		APP	SCALE 1 = 1 WT	

92125010232

ARH-C-00020

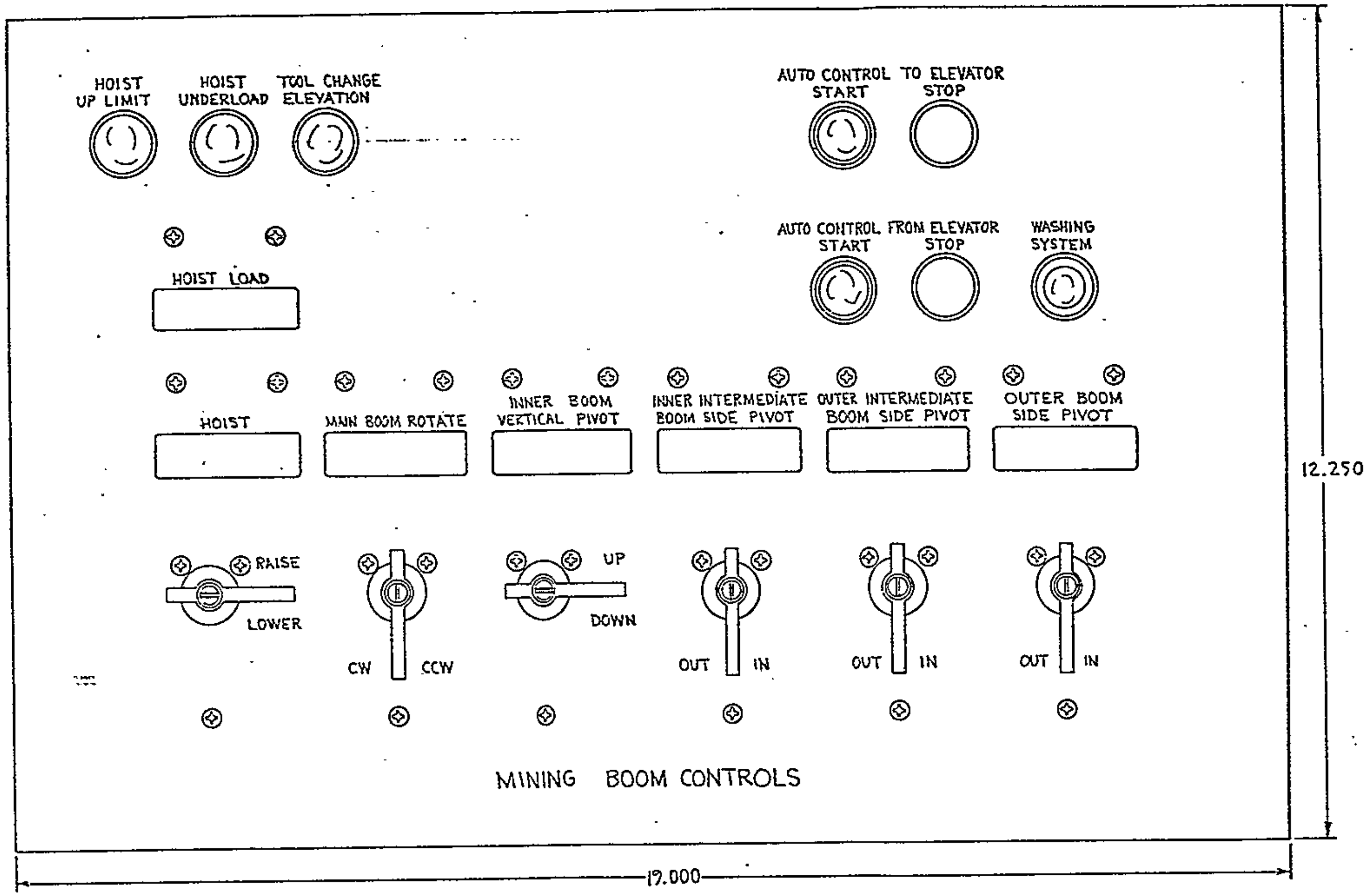


FIGURE 21-4

MATERIAL		PROGRAMMED AND REMOTE SYSTEMS CORP.		
		ORIG. DATE 3-15-77	NAME MINING BOOM CONTROL PANEL	NEXT ASSY.
HEAT TREATMENT	FINISH			PROJECT NO. 5004
				SHEET 1 OF 1 REV.
			SCALE 1=1	DWG. NO. P-21556-D

9 2 1 2 5 0 1 0 2 8 3

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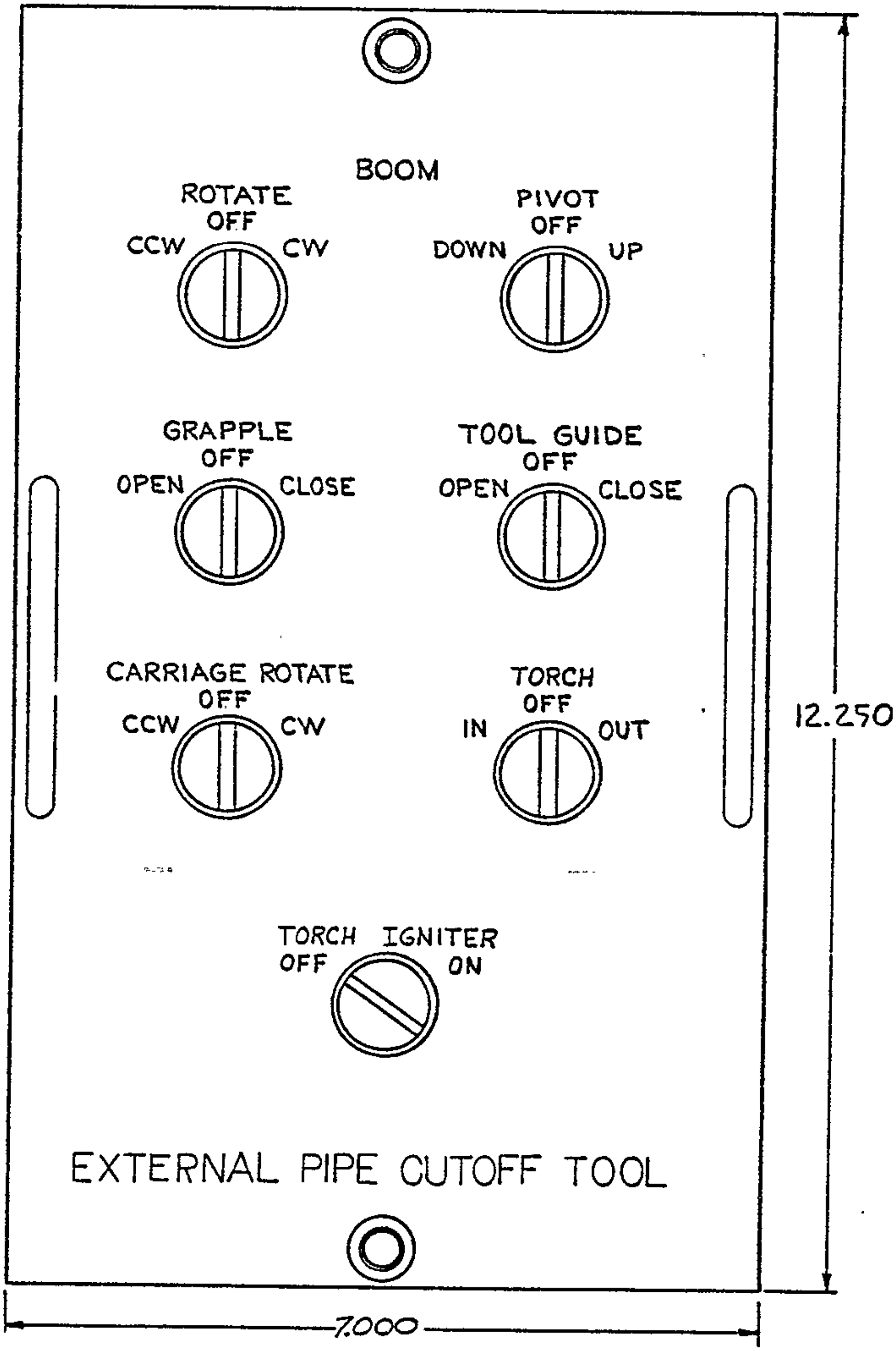

FIGURE 21-5
EXTERNAL PIPE CUTOFF TOOL CONTROL MODULE
(DWG. NO. P-21559-C)

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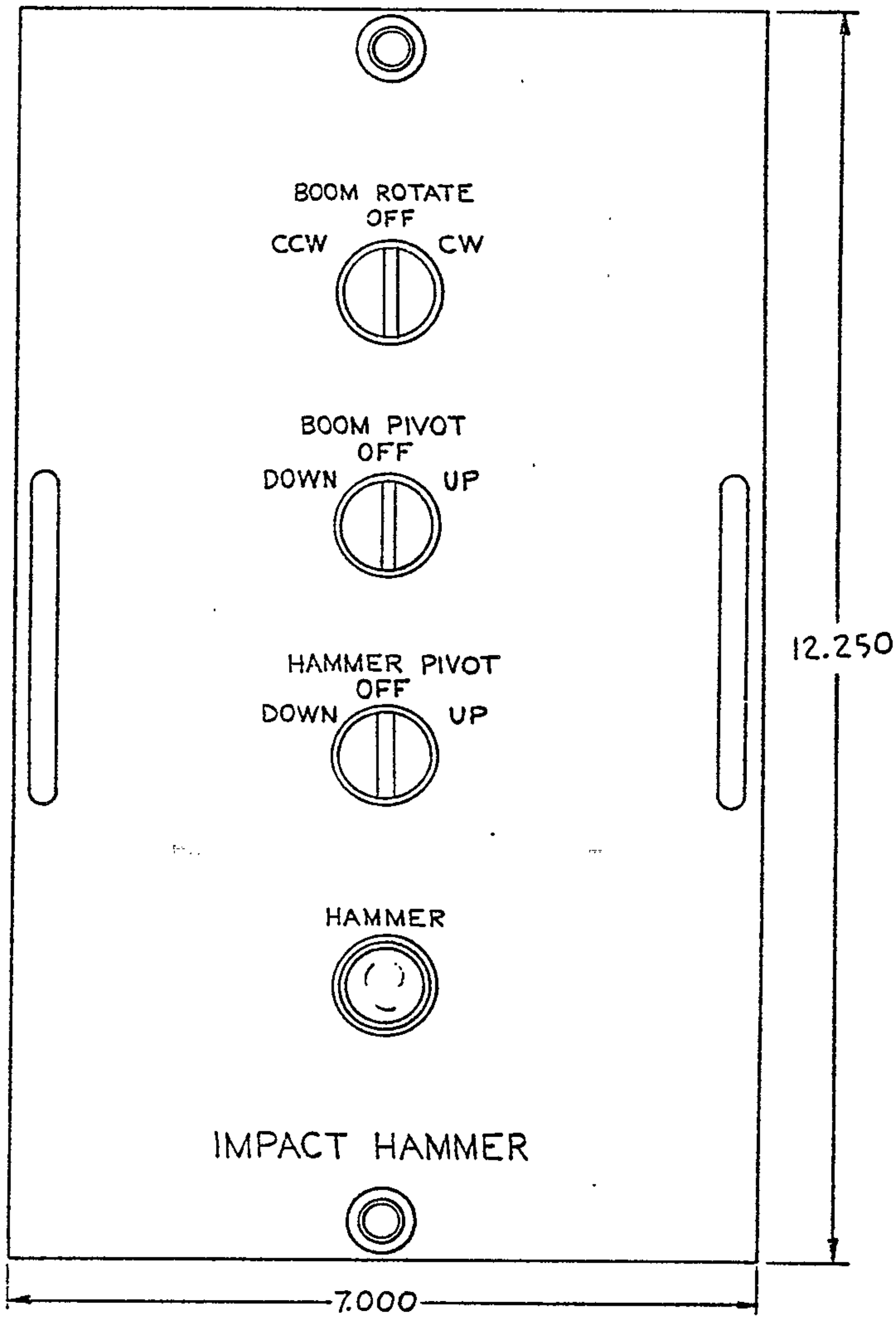

FIGURE 21-6
IMPACT HAMMER CONTROL MODULE
(DWG. NO. P-21560-C)

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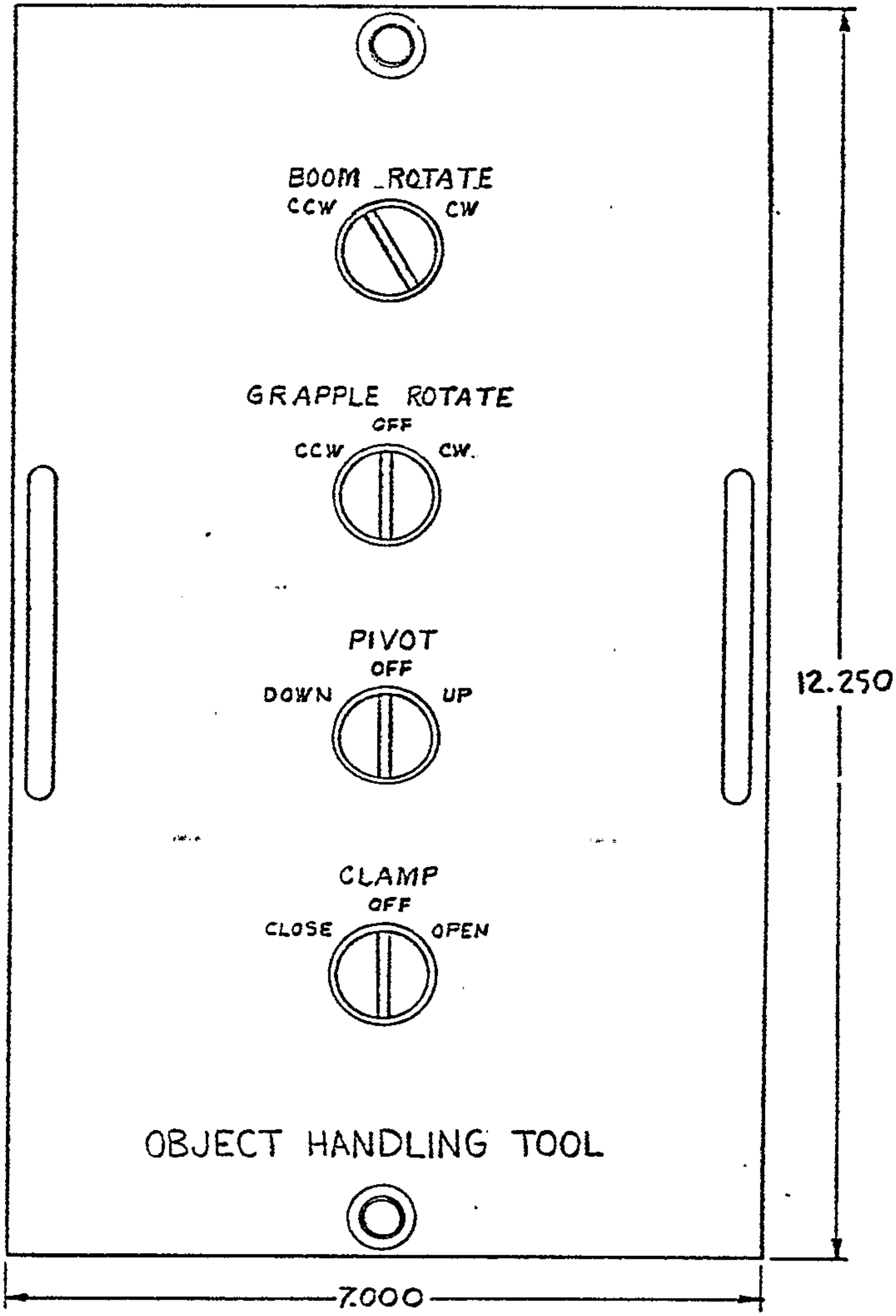

FIGURE 21-7
OBJECT HANDLING TOOL CONTROL MODULE
(DWG. NO. P-21561-C)

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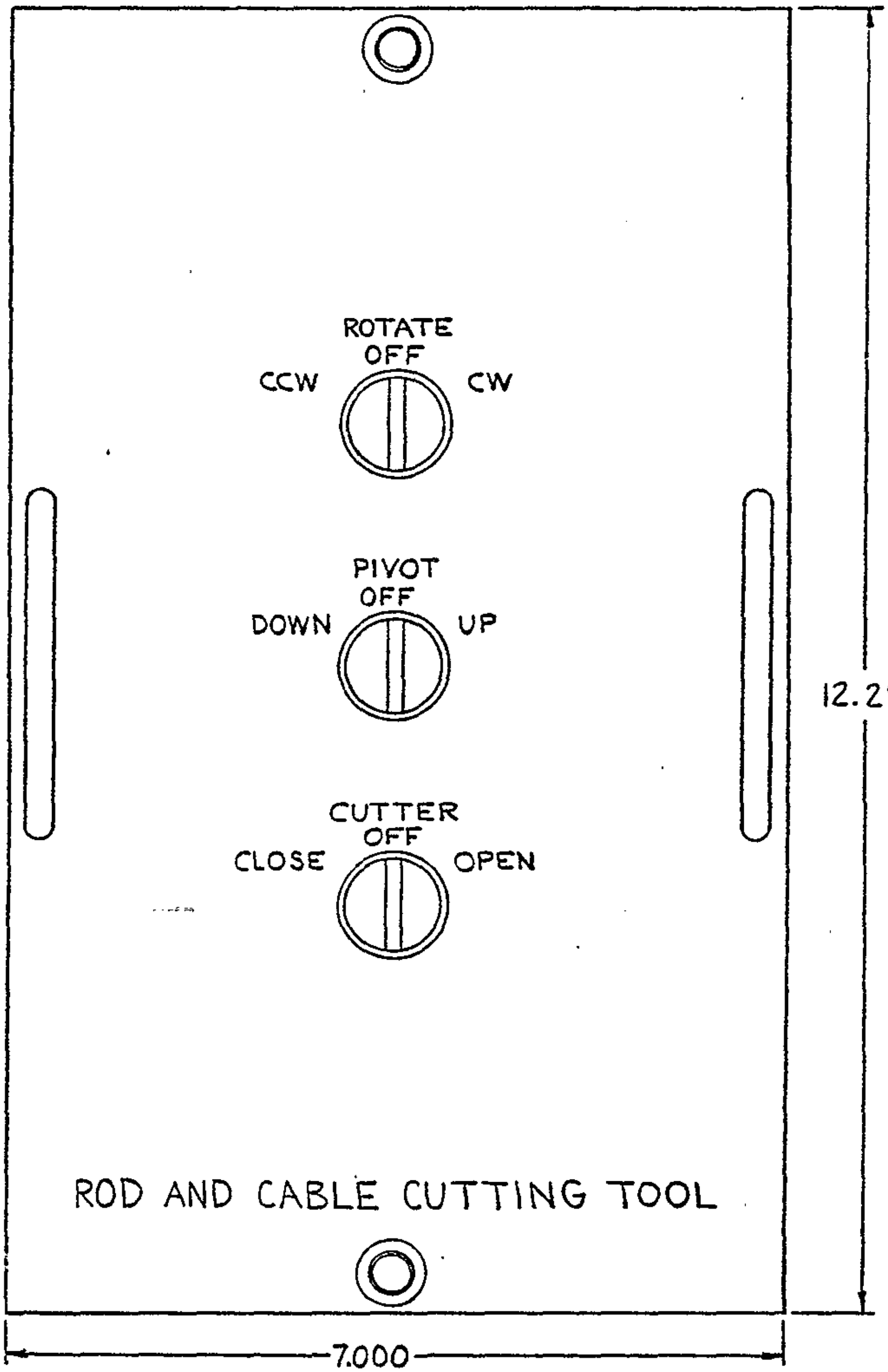

FIGURE 21-8
ROD & CABLE CUTTING TOOL CONTROL MODULE
(DWG. NO. P-21562-C)

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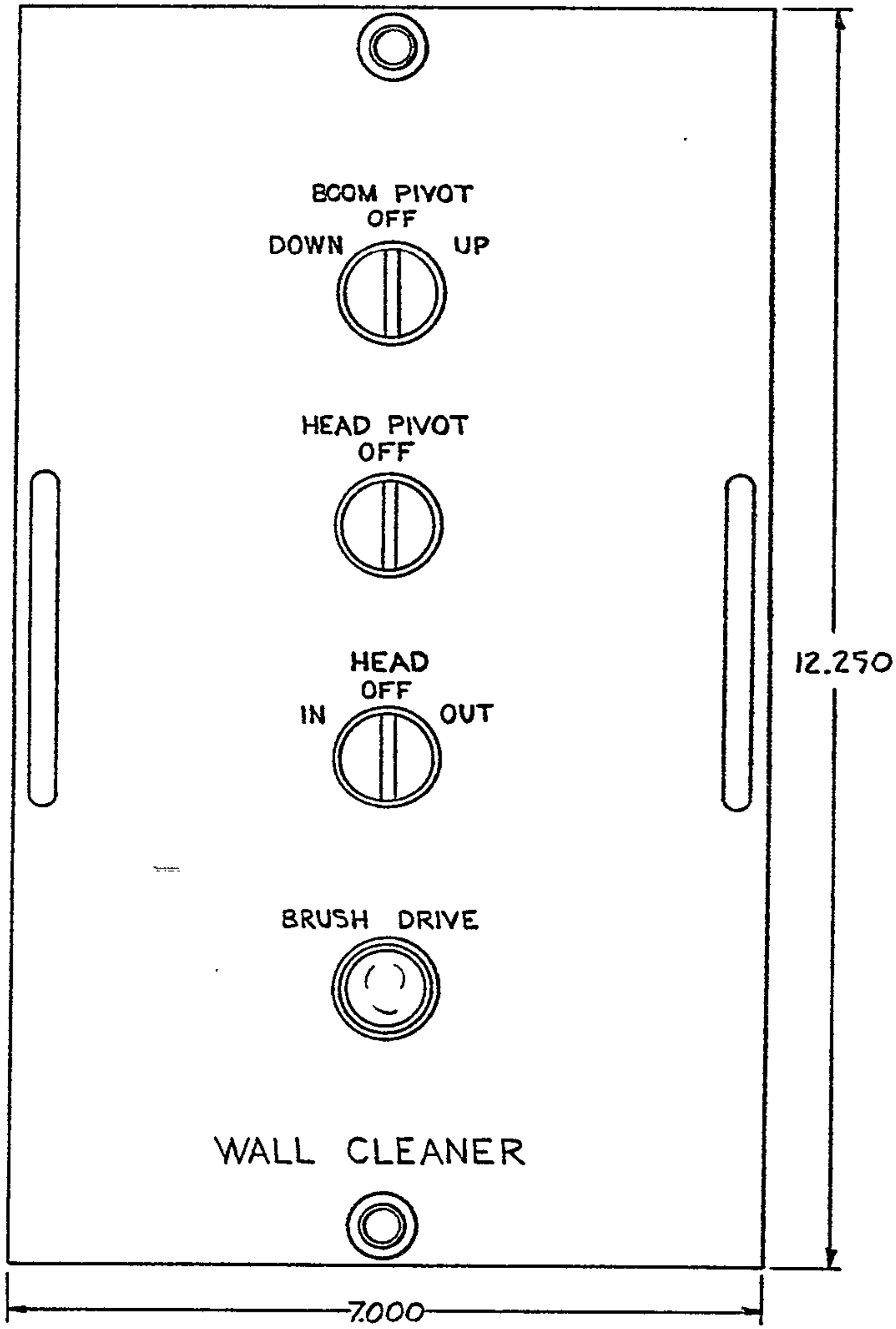

FIGURE 21-9
WALL CLEANER CONTROL MODULE
(DWG. NO. P-21563-C)

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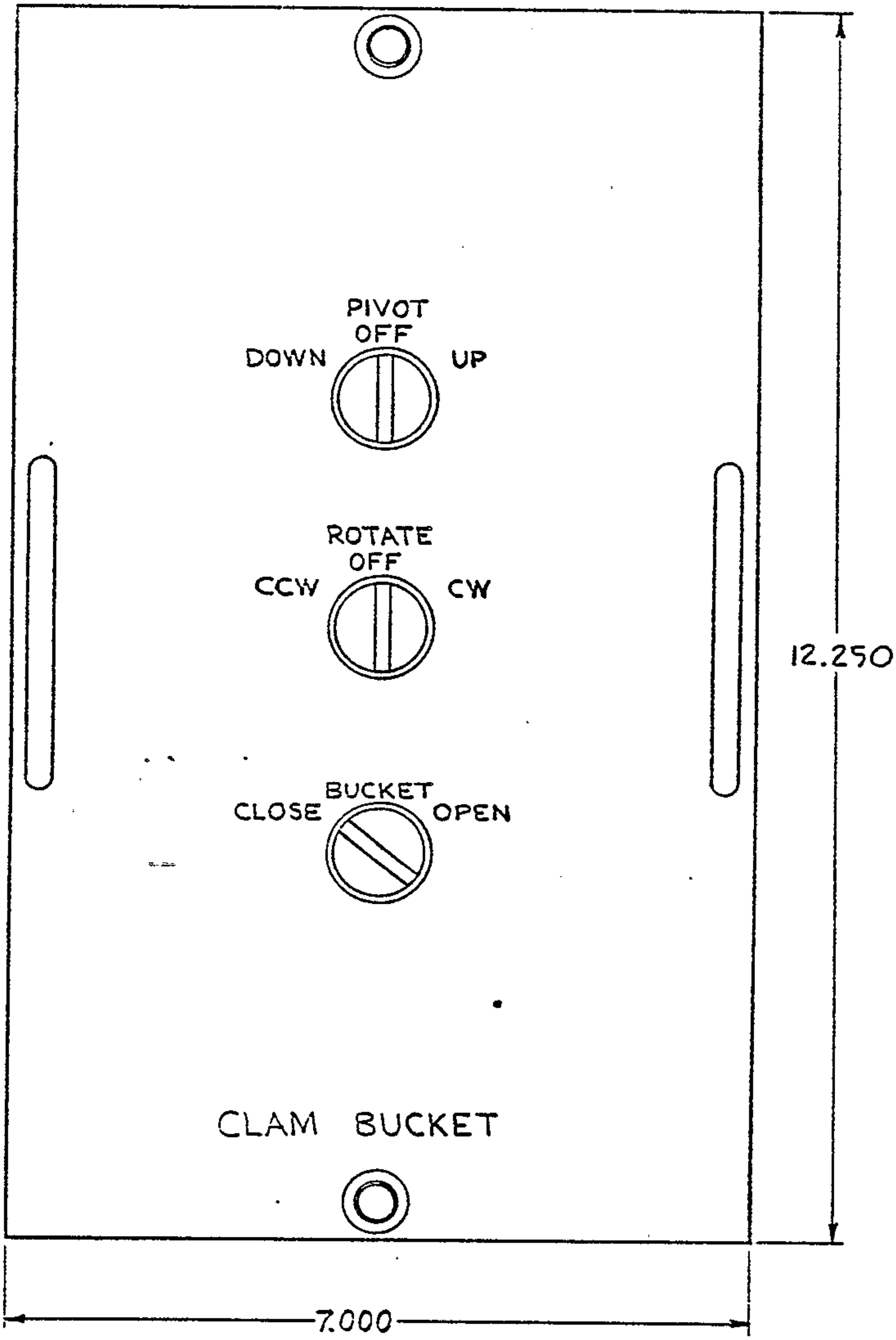

FIGURE 21-10
CLAM BUCKET CONTROL MODULE
(DWG. NO. P-21564-C)

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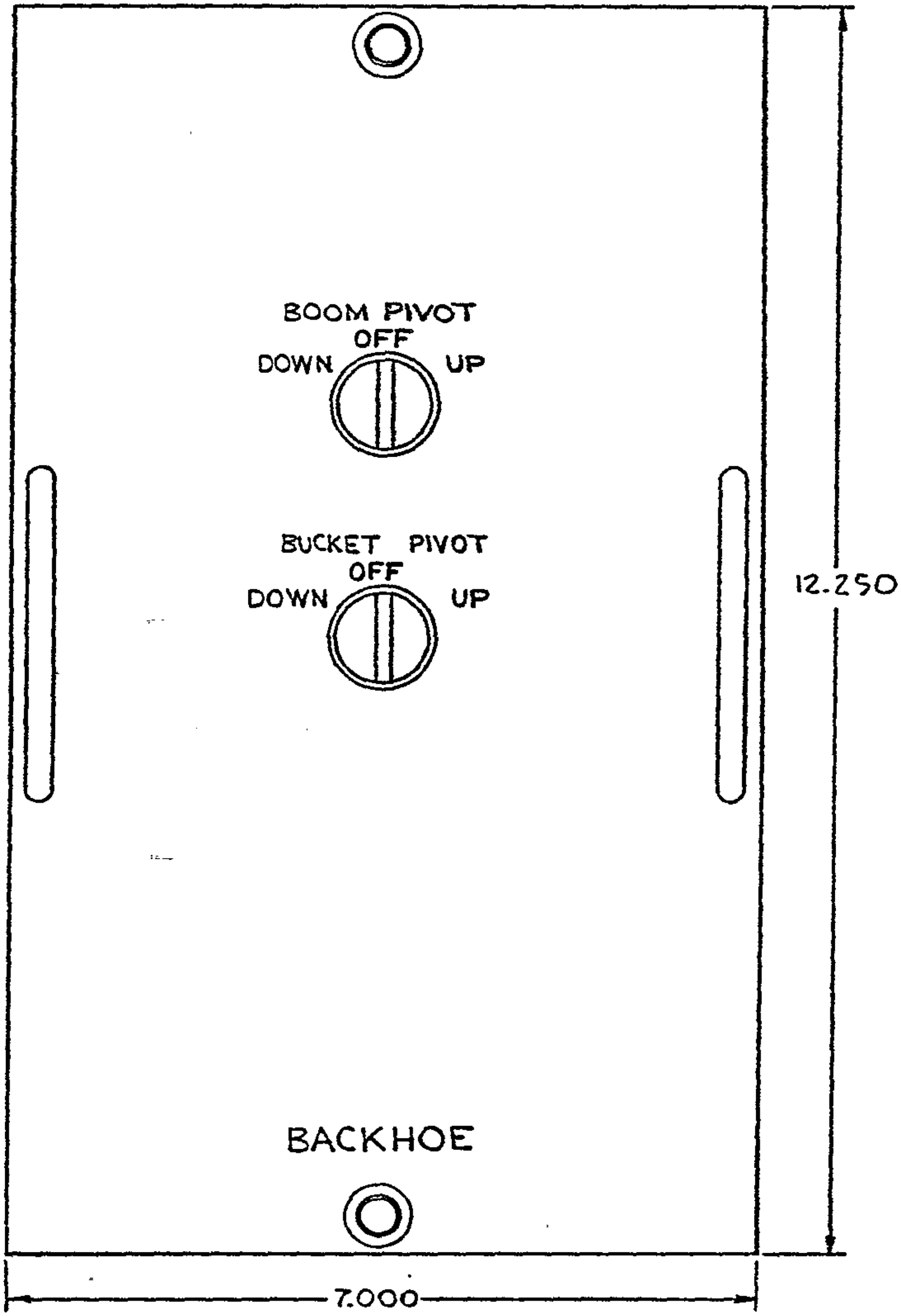

FIGURE 21-11
BACKHOE CONTROL MODULE
(DWG. NO. P-21565-C)

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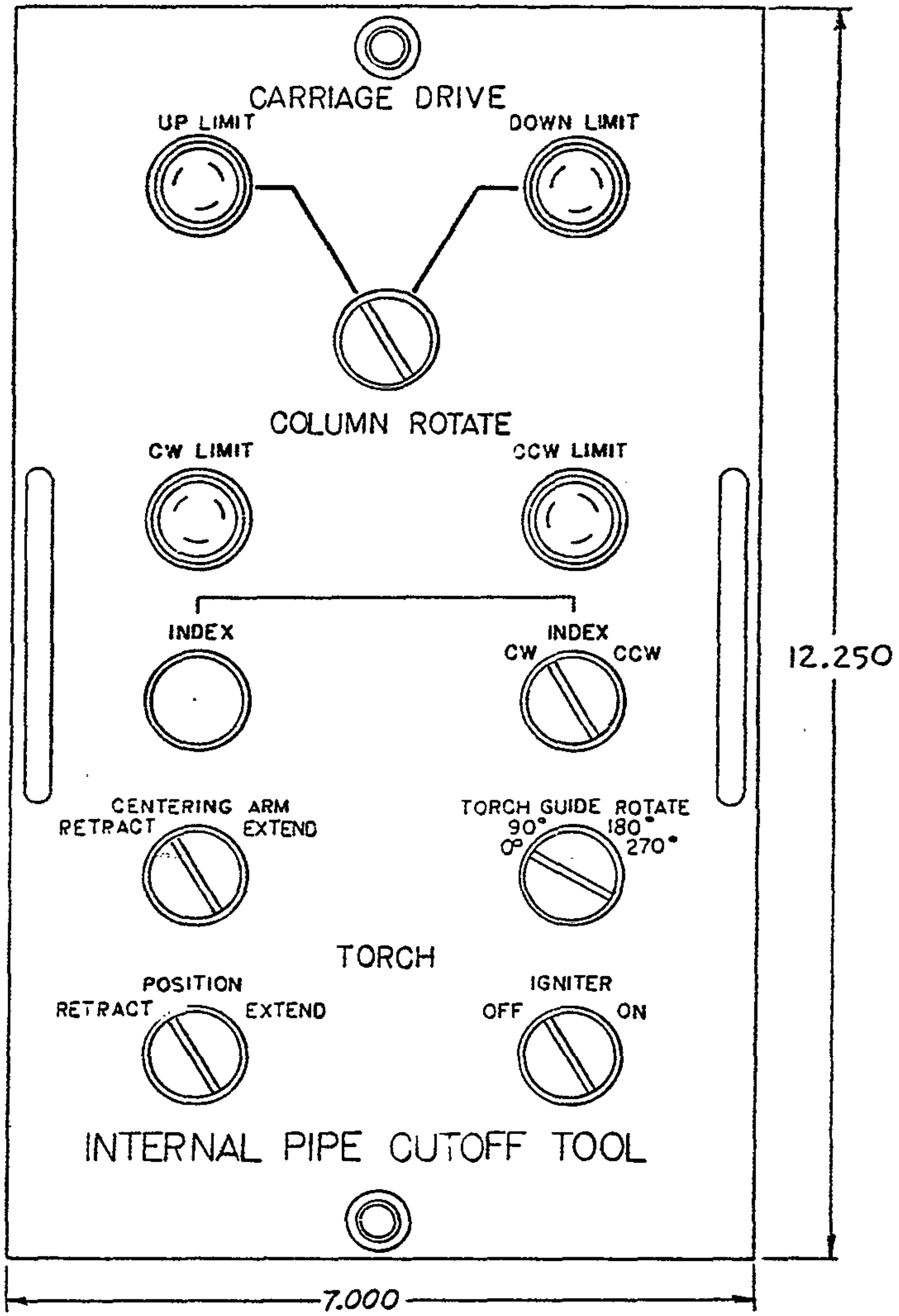

FIGURE 21-12
INTERNAL PIPE CUTOFF TOOL CONTROL MODULE
(DWG. NO. P-21706-C)

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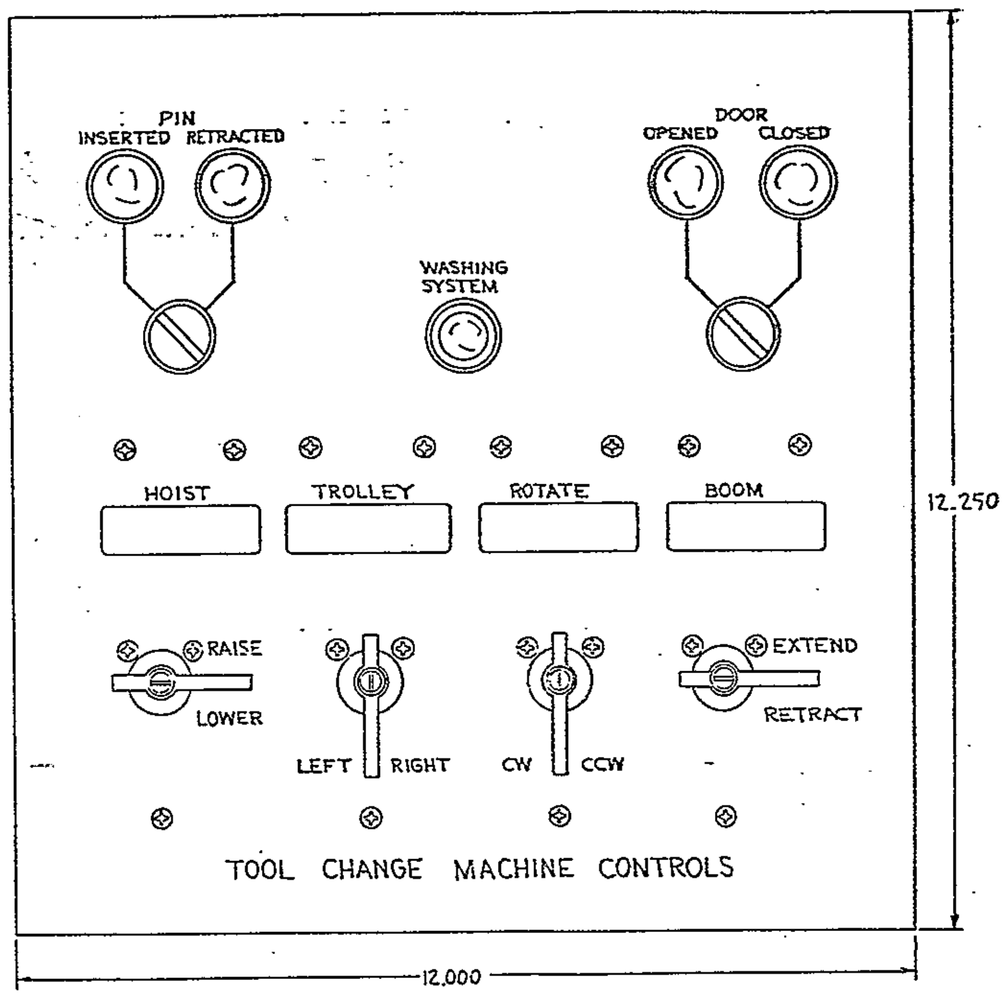

FIGURE 21-13

MATERIAL	PROGRAMMED AND REMOTE SYSTEMS CORP.	
ORIG. DATE 3-15-77	NAME TOOL CHANGE MACHINE CONTROL PANEL	NEXT ASSY.
		PROJECT NO. 5004
HEAT TREATMENT	FINISH	SHEET 1 OF 1 REV.
	SCALE 1=1	DWG. NO. P-21557-D

9212501 0292

B CHANGED DOOR NOMENCLATURE 5-16-77

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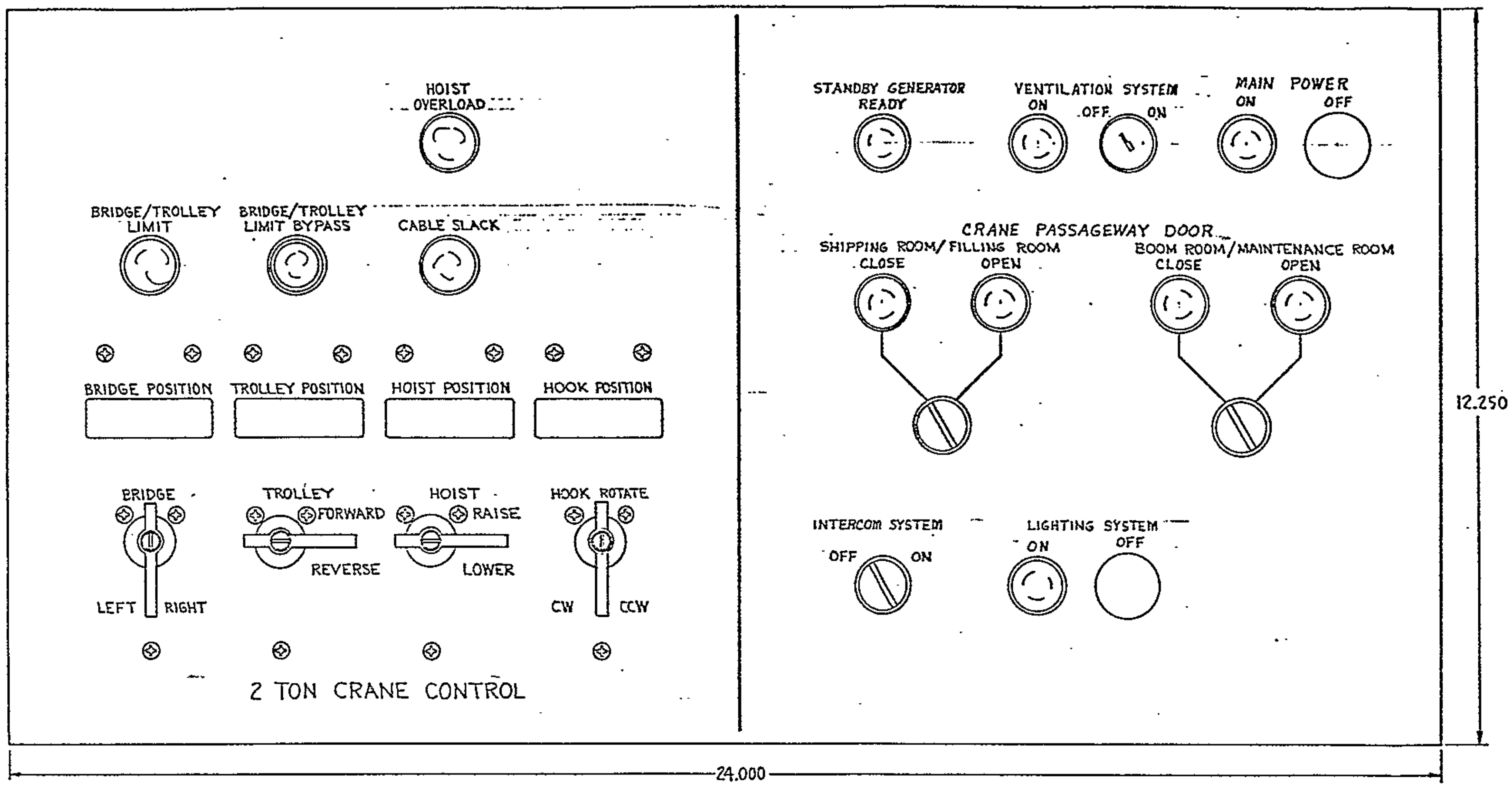

FIGURE 21-14

		PROGRAMMED AND REMOTE SYSTEMS CORP.		
MATERIAL		ORIG. DATE 3-14-77	NAME 2 TON CRANE & MISCELLANEOUS CONTROL PANEL	NEXT ASSY.
		DR		PROJECT NO. 5004
HEAT TREATMENT	FINISH	CHK		SHEET 1 OF 1 REV.
		CHG		DWG. NO. P-21558-D B
		APP	SCALE 1=1 WT	

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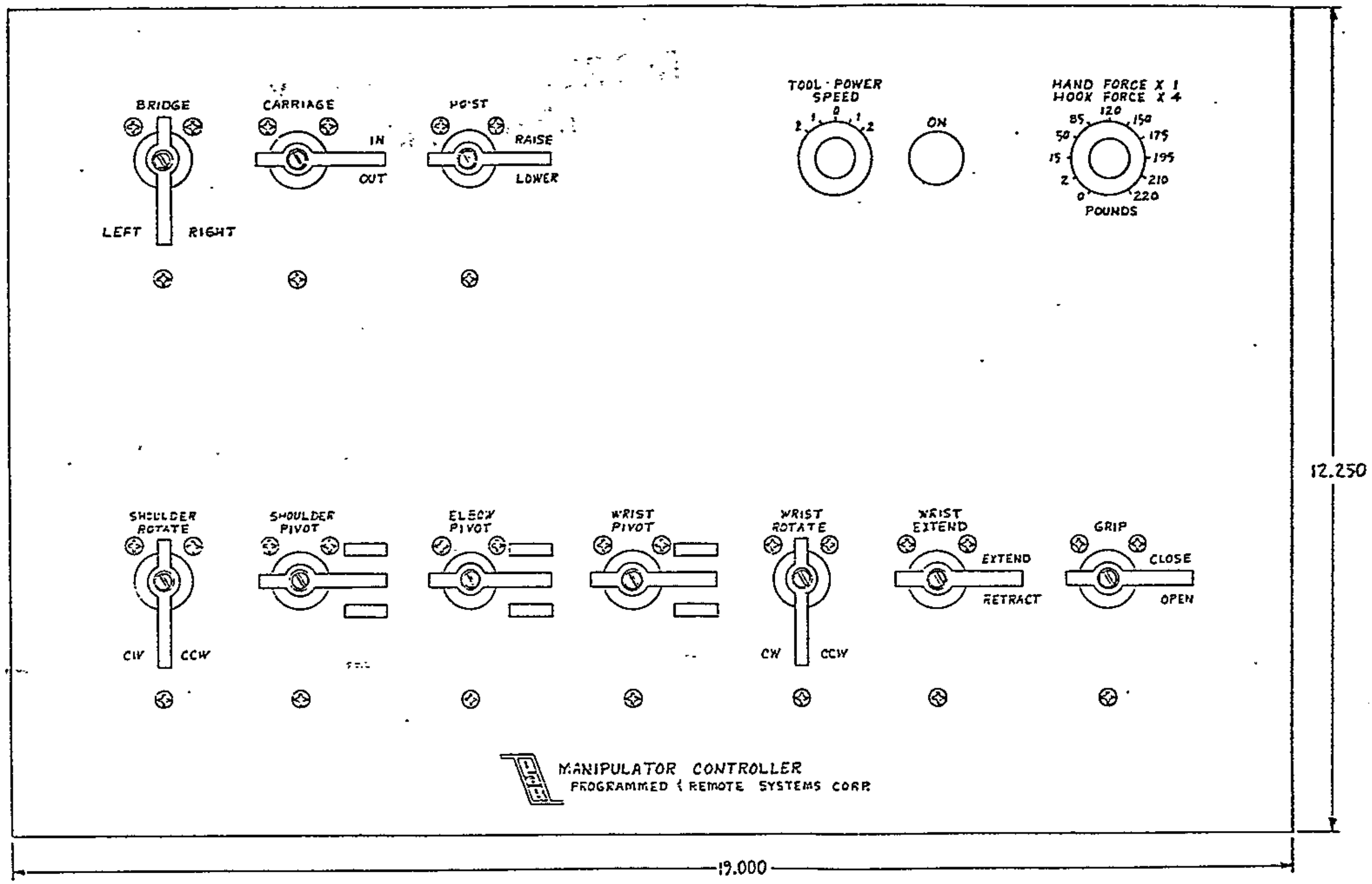

FIGURE 21-15

PROGRAMMED AND REMOTE SYSTEMS CORP.

MATERIAL	UNLESS OTHERWISE SPECIFIED TOLERANCES IN INCHES ARE:	DWG DATE 4-2-77	NAME MODEL 3000 MANIPULATOR CONTROLLER PANEL	NEXT ASSY
		DR		PROJECT NO 5034
HEAT TREATMENT	FINISH	CHK		SHEET OF REV.
		ENG		DWG NO P21707-C
		APP	SCALE 1:1 WT	

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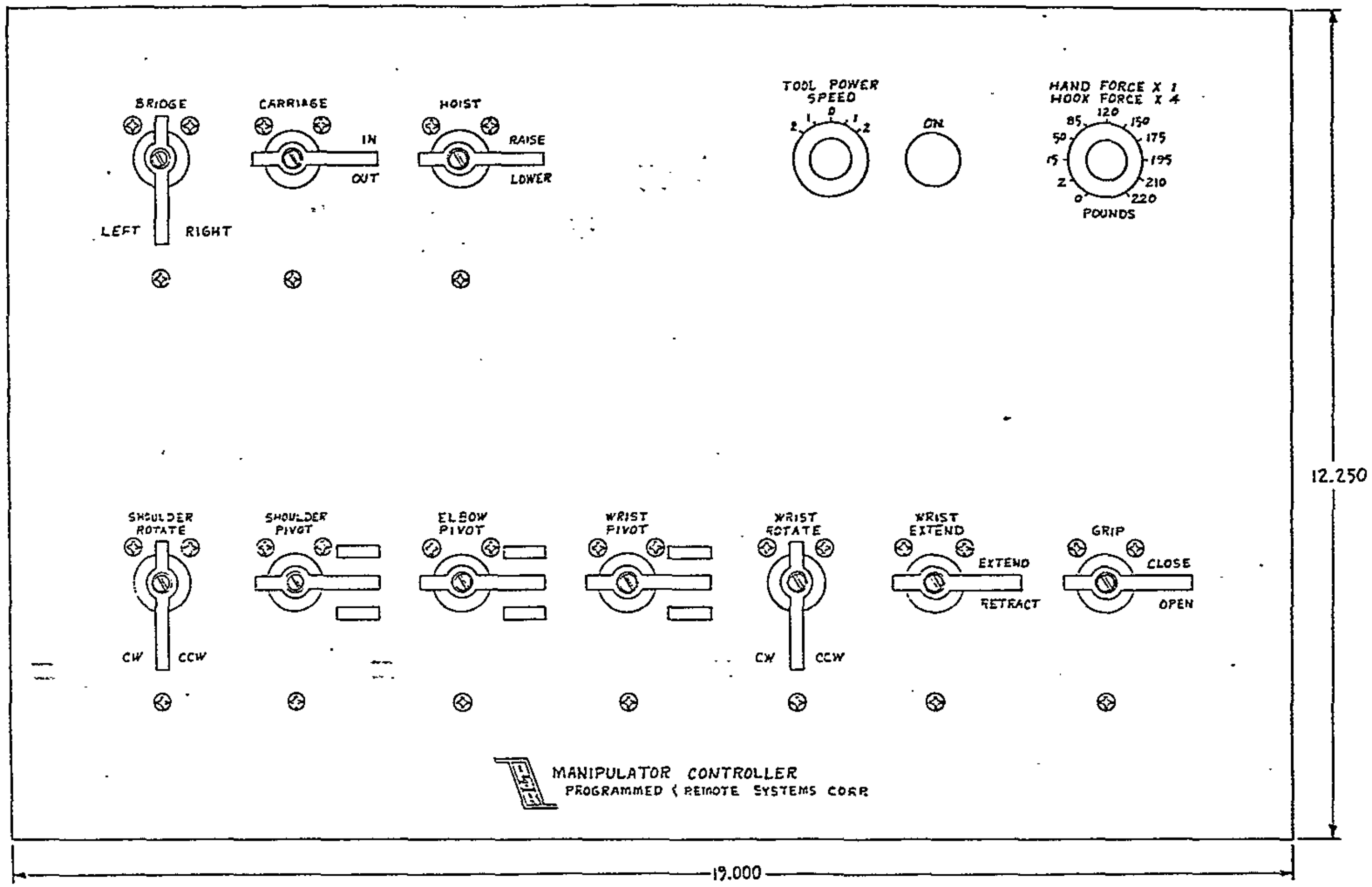

FIGURE 21-15

	PROGRAMMED AND REMOTE SYSTEMS CORP.		
MATERIAL	ORIG DATE 4-12-77	NAME MODEL 3000 MANIPULATOR CONTROLLER PANEL	NEXT ASS'Y
	DR		PROJECT NO. 5004
HEAT TREATMENT / FINISH	CHK		SHEET OF / REV.
	ENG		DWG NO P-21707-D
	APP / SCALE		

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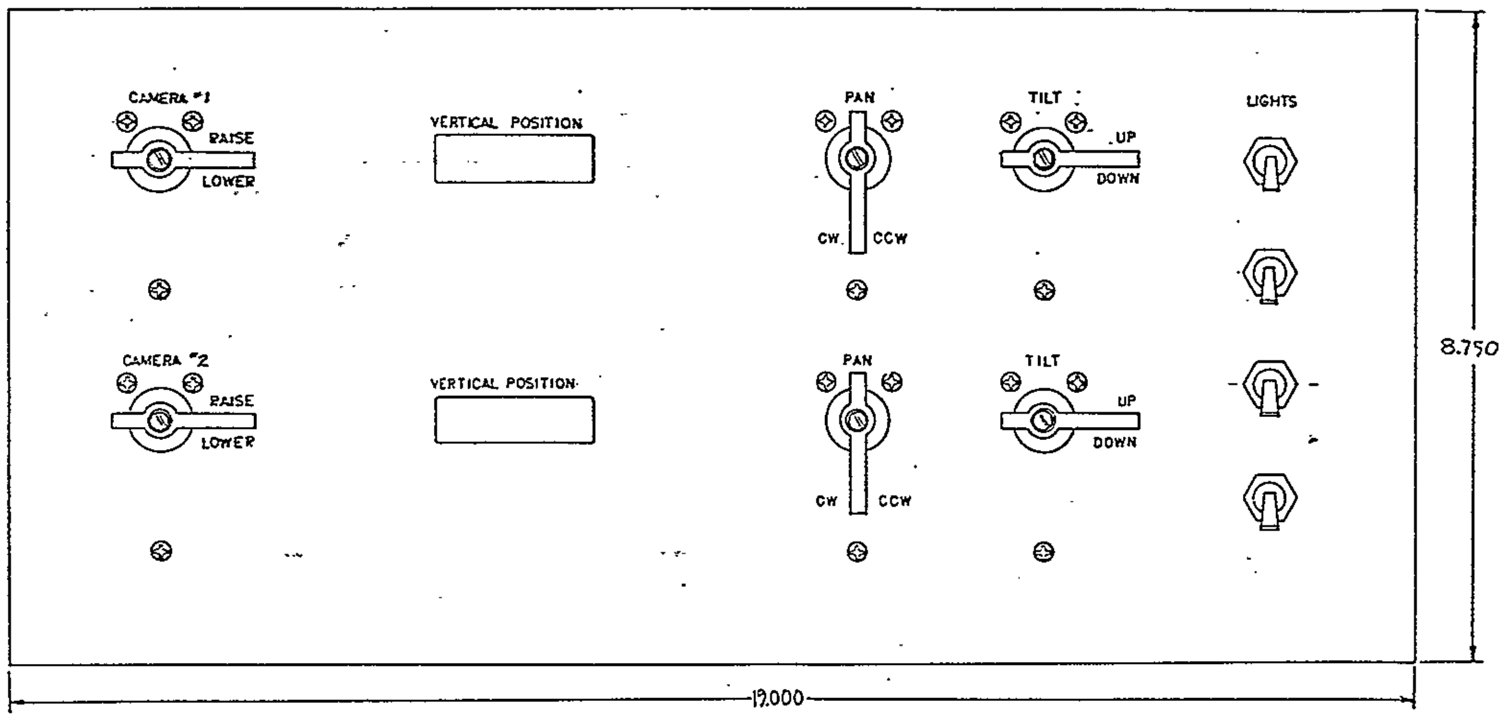

FIGURE 21-16

PROGRAMMED AND REMOTE SYSTEMS CORP.	
MATERIAL	HEAT TREATMENT
FINISH	
ORIG. DATE 4-13-77	NAME TV POSITIONER CONTROLS
SCALE 1:1	WT
NEXT ASSY.	
PROJECT NO. 5004	
SHEET 1 OF 1	REV.
DWG. NO. 221705-D	

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A	TRAILER WAS VAN HANDLING MACH. SHIFT WAS RENOVAL TOOL		KF

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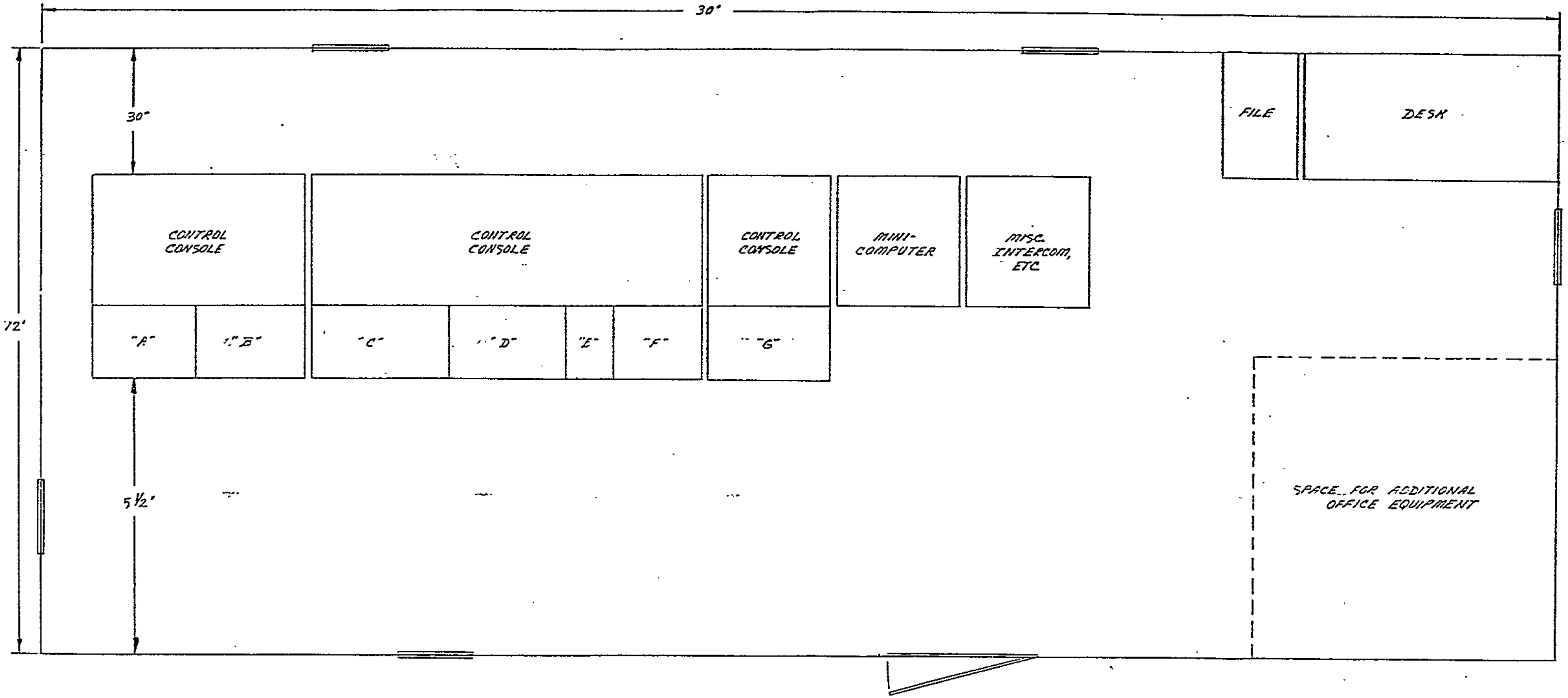

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REFERENCE DRAWING: P-21601-D

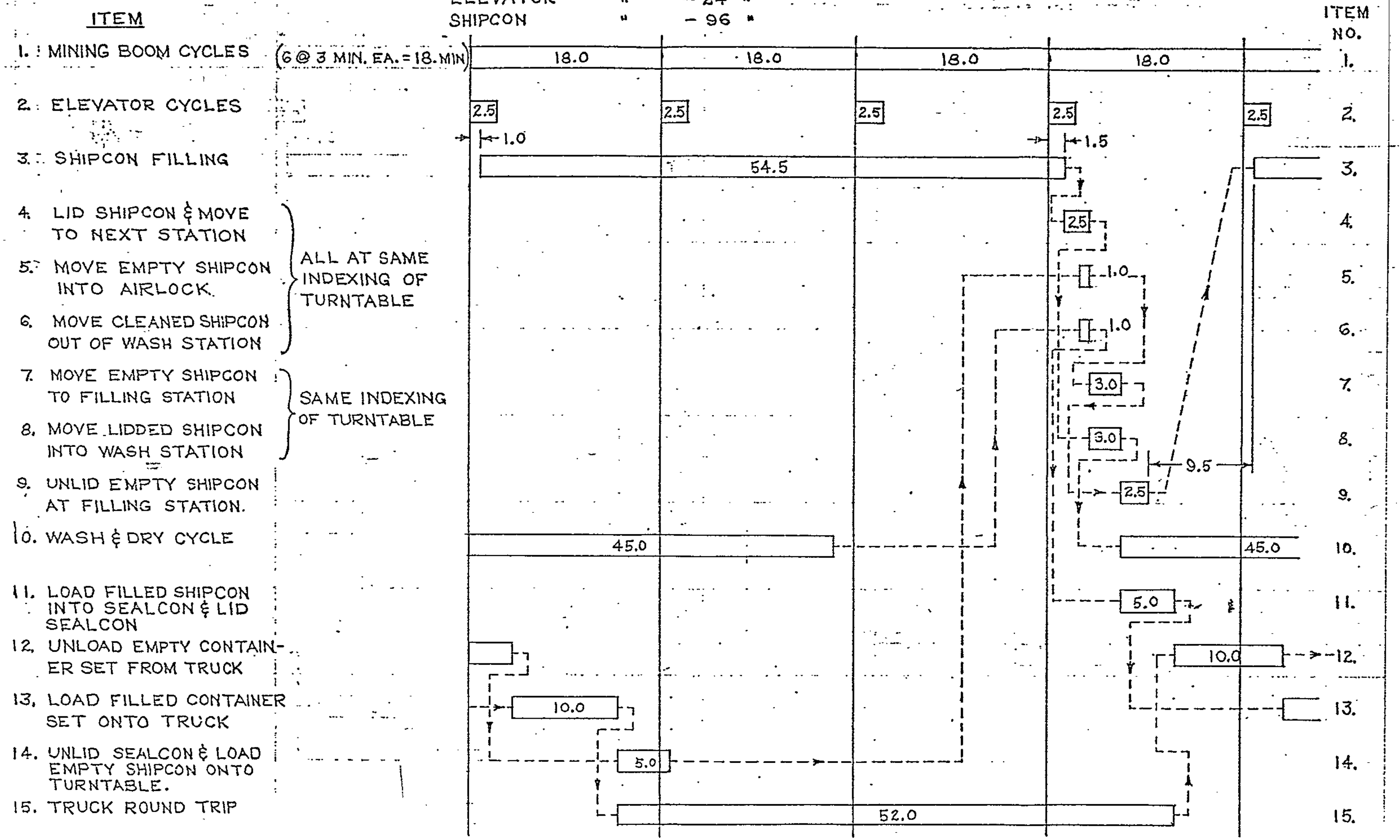
CONTROL PANEL	DESCRIPTION
A	MODEL 3000 MANIPULATOR
B	20-TON CRANE & TURNTABLE
C	LID HANDLING MACH. & MATERIAL ELEVATOR
D	MINING ROOM
E	TOOL CONTROL
F	TOOL CHANGE MACHINE
G	2-TON CRANE & MISCELLANEOUS
H	T/ POSITIONER CONTROLS

FIGURE 21-18

	PROGRAMMED AND REMOTE SYSTEMS CORP.
MATERIAL	ORIG. DATE 4-5-77
HEAT TREATMENT / FINISH	NAME: REMOTE CONTROL TRAILER LAYOUT
NEXT ASSY.	PROJECT NO. 5004
SHEET 1 OF 1	REV. A
SCALE 1/2/1"	DWG NO. P21684-D

FIGURE 22-1. TIMING CHART FOR FILLING & SHIPPING OPERATIONS; ONE CONTAINER SET PER TRUCK

CLAM BUCKET CAPACITY – 4 FT³
ELEVATOR " – 24 "
SHIPCON " – 96 "



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these hoist conditions and will stop hoist lowering and hoist raising, respectively.

The 2-ton crane moves into the maintenance areas from the tool storage area via the tool washdown chamber. This is accomplished by operator control utilizing the position readouts.

MISCELLANEOUS CONTROLS

A control panel with miscellaneous controls is shown on PaR Figure 21-14. This control panel mounts the necessary controls to control and govern the following:

1. Main Power
2. Ventilation System
3. Standby Generator
4. Crane Passageway Doors
5. Intercom System
6. Lighting System

MODEL 3000 MANIPULATOR CONTROLS

The control panel for the Model 3000 Manipulator is shown on Figure 21-15. Control fingerswitches provide variable speed control for the hoist, bridge, carriage, and manipulator motions. In addition, a selector switch and pushbutton provide two-speed, reversible tool power. The grip force is adjusted via a rheostat.

TV POSITIONER CONTROLS

The controls for the in-tank TV and lighting system are shown on Figure 21-16. Each panel controls two cameras and associated lighting. Fingerswitches control the raise, lower, pan, and tilt motions of the camera. Position readouts are provided for the vertical position of the camera. Lights are controlled by on-off switches.

21.1.2 GRAPHIC DISPLAY SYSTEM

The graphic display system consists of a computer-driven CRT which continuously displays a "top view" of the mining boom, elevator location, and obstacles. A typical view is shown in Figure 21-17.

The minicomputer calculates the position of the end of each mining boom section, and generates the signals necessary to drive the CRT display.

The minicomputer also performs the necessary computations to prevent the mining boom from striking any preset obstacles. Obstacles can be entered (and displayed) at any time via keyboard entry. Obstacles can also be "erased" (via the keyboard) as they are removed.

21.1.3 CONTROL CENTER TRAILER

As mentioned previously, the remote controls are housed in a trailer. A typical arrangement of the trailer is shown on Figure 21-18. The layout allows ample operator area and access to the rear of the cabinets. The 12 x 30-foot trailer also has a desk and file cabinet. Space is available for additional chairs, desks, tables, etc.

21.2 LOCAL CONTROL SYSTEM

The local, or on-board, control system consists of a power center area and local control panels.

The power center area is located inside the waste retriever near the personnel room. The power center room contains cabinets which house all of the necessary motor drivers, contactors, transformers, etc. A minicomputer system is also housed in this room. The minicomputer, with its input/output interfaces, generates the necessary control interlock signals for the overall control system. The minicomputer also communicates with the remote control minicomputer to transmit and receive commands, position information, etc.

The local control panels are located inside the personnel corridor and hard-wired to allow operation of each machine from its own control panel while directly viewing the various machines. Each control panel will have the same controls shown on the remote control panels and also a "Local/Remote" selector switch.

The local controls are used during maintenance periods, initial testing, pre-operation test and checkout, and emergency situations.

21.3 INTERCOM SYSTEM

An extensive intercom system provides two-way communications between the control van and the waste retriever. Speakers in the waste retriever are located in the power center room, the personnel corridor, and the maintenance room. Each speaker has its own volume control.

Microphones are located in the personnel areas of the waste retriever, inside the various rooms within the retriever, and inside the tank. This allows the operators to detect any unnatural equipment sounds or personnel comments.

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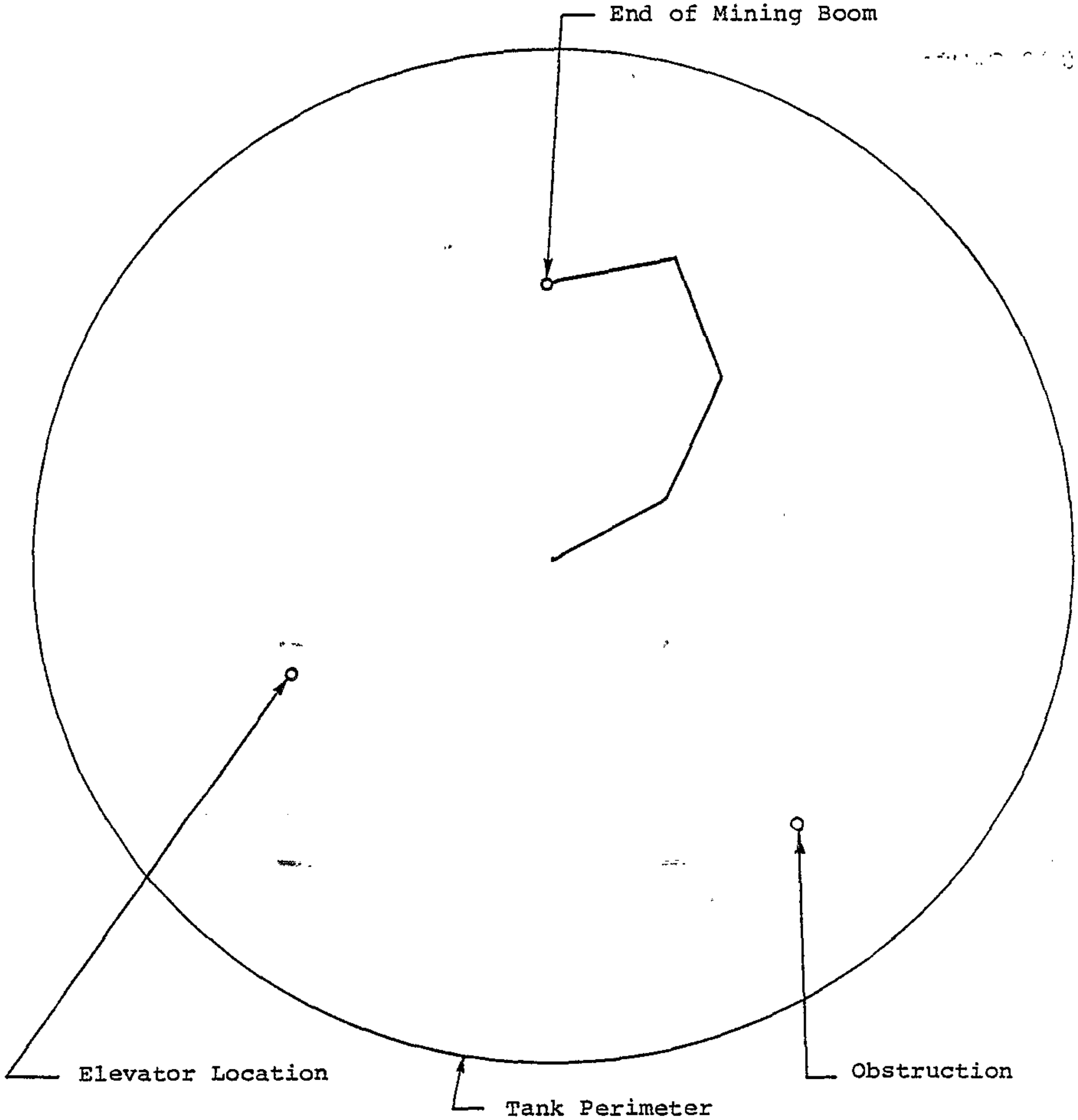

Figure 21-17

TYPICAL GRAPHIC DISPLAY SCENE

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22.0 CYCLE TIME ANALYSIS

22.1 MINING BOOM

The specified material removal rate is 500 gal/hr or 67 cubic feet/hr. With a 4 cubic foot clam-bucket, this requires 17 buckets/hr. or 1 bucket/3.5 minutes.

The mining boom controls are such that the boom will take the shortest path from the digging location to the elevator. Thus the maximum travel will be 180 degrees, the minimum 0 degrees and the mean travel 90 degrees. At the maximum rotational speed of 1/2 RPM, the boom will take 30 seconds to travel 90 degrees. Allowing 5 seconds each for acceleration and deceleration, a boom rotate travel time of 40 seconds results. Since the boom pivot motions are faster than the main rotate, and/or have smaller mean travels, they will reach their required positions within the 40 second travel time.

The outer boom down pivot has a maximum travel of 60 degrees, (about 6 ft.) at 1 RPM. Full travel at 1 RPM will require 10 seconds. To allow for acceleration and deceleration, and based on a mean travel of 5 feet, a raise and lower time of 14 seconds is used.

An average time cycle for the mining boom is:

Operation	Time (Seconds)
Fill bucket	30
Raise bucket	14
Travel to Elevator	40
Dump load	30
Travel to digging location	40
Position bucket	12
Lower bucket	14
Total	180 = 3.0 minutes

This provides a reserve of 0.5 minutes on the required cycle time of 3.5 minutes or about 8.5 minutes reserve per hour.

22.2 MATERIAL ELEVATOR

The elevator travels at 60 ft/min and has an average travel of 45 feet. To allow for accelerations, it is assumed that the travel time for 45 feet is 1 minute.

An average time cycle for the elevator is:

Operation		Time (Seconds)
Raise		60
Dump load		30
Lower		60
	Total	150 = 2.5 minutes

The elevator bucket has a capacity of 24 cubic feet and this is filled by 6 clam shell bucket loads. The elevator will be moved every 18 minutes and can be emptied and returned without delaying the mining boom cycle.

22.3 SHIPPING CONTAINER

The proposed shipping container has a capacity of 96 cubic feet and will hold 4 elevator bucket loads. A shipping container will be filled every 72 minutes. This is the average rate at which a load of waste material (96 cubic feet or 10,180 pounds at a specific gravity of 1.7) will be delivered to the processing plant.

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22.4 SHIPPING & RECEIVING ROOM & FILLING ROOM OPERATIONS (Ref: Figure 22-1)

The sequence of operations for handling the containers in the shipping and receiving room and filling room is described in section 8.1. Figure 22-1 is a timing chart showing how these handling operations are performed in relation to the mining boom, material elevator, and trucking functions.

The 18-minute interval between elevator travels is the time available in which to move a loaded shipcon away from the filling station and replace it with an empty one. As shown in Figure 22-1, this interval is adequate for performing the operations involved in the replacement process. In fact, on the average the empty container will be in position 9.5 min. before the material elevator arrives with the first bucket load.

The shipping container will be at the filling station in the process of being loaded for a period of 54.5 minutes. The one-minute interval at the start of the first 18-minute period is the time required for the elevator to come up from the tank. Similarily, the 1.5 minute interval at the end of the third 18-minute period is the time for the elvator to come up and finish dumping the load.

The progress of a filled container through the various operations can be followed readily by tracing via the dashed lines. By doing so one eventually arrives back at the point where an empty shipcon is in position at the filling station ready to start another filling cycle.

Of the 45 minutes allowed for the wash and dry cycle, approximately 5 minutes is devoted to the washing operation and 40 minutes is available for drying.

Figure 22-1, shows that a period of 52 minutes is allowed for the truck to make a round-trip from retrieval site to processing plant and return. The shipping cell operating cycle, is based on hauling one container per truck trip. An empty set of containers is carried back to the site on the return trip. It is recommended that two trucks be dedicated to each waste removal system to insure continuous movement of waste in the event of a truck breakdown.

23.0 MAINTENANCE REQUIREMENTS (Ref: Figure 22-1)

Because of the importance of providing a continuous supply of waste material to the processing plant, the waste retriever is designed to proivde for on-board maintenance of retrieval equipment. Non-contact maintenance is performed on equipment within the mining boom room and the filling room of the retriever . Contact maintenance is performed on tools and equipment components in the maintenance room.

The general maintenance objective is to minimize shutdowns for equipment repair by following a preventive maintenance program. This program will provide for scheduled servicing on a regular basis and for parts replacement at the end of expected service life. In the event of premature failures, the recommended plan is to replace sub-assemblies with spares rather than attempt on-board repairs to component parts.

Preventive maintenance will be performed during the third shift (assuming that there will be two operating shifts daily).

It is planned that general maintenance and replacement of high usage components will be performed on the system each time it is shut down for movement between tanks. This interval shown in the schedules as "per tank" may vary from a few months to a year or more depending upon the amount and type of material in the tank and the overall efficiency of operation.

Some of the equipment items are used regularly in the container filling and shipping operations. The cycle time of 72 minutes (reference Figure 22-1) shown in the schedules as "per cycle" is used to indicate the usage of these items.

At intervals of 2 to 3 years, motors, pumps, cylinders and other operating components should be replaced.

Following is a list of the major equipment items of the Prototype Retrieval System, with estimated maintenance and component replacement schedules for each. The relative usage of each item and the requirement for wash-down prior to servicing are indicated.

The last section lists the recommended replacement schedule of several items of equipment. If only these items pertain to a given equipment item, the word "general" is used under component replacement.

1. 20-Ton Crane

   Usage: Approximately 30 minutes per cycle

   Wash-down: Not Required. Normal operation is in clean area only

   Maintenance: - inspect hoist cable — monthly
   - lubrication & adjustment — monthly

   Component Replacement: - hoist cable — as required or per tank

2. Turntable

   Usage: One revolution per cycle

   Wash-down: Not generally required. It is washed during operation. Additional wash-down may be required between tanks.

   Maintenance: -lubrication and adjustment — monthly

   Component Replacement: - general

3. Shield/Air Locks & Container Wash Station

   Usage: One operation per cycle

   Wash-down: Required for major maintenance

   Maintenance: - lubrication, adjustment and replacement of seals — per tank

Component Replacement: - lift cables per tank

4. Lid Handling Tool

   Usage: One use per cycle

   Wash-down: Required

   Maintenance: - lubrication & adjustment per tank

   Component Replacement: - general

5. Material Elevator

   Usage: Four operations per cycle

   Wash-down: Required

Maintenance:	- inspect hoist cable	monthly
	- inspect and lubricate hoist	6 months
	- inspect and adjust cylinders and linkages	per tank
	- replace bucket door seals	per tank
	- lubricate and adjust guide rollers	per tank
Component Replacement:	- hoist cable	as required or per tank

6. Wash-down Water System

   Usage: Once per cycle for container washing
   Once per tool change
   Once per elevator and mining boom maintenance

   Wash-down: Required

   Maintenance: - inspect and lubricate per tank

   Component Replacement: - general

7. Hydraulic Power Units

<u>Usage:</u> Continuous

<u>Wash-down:</u> Not required. They are located in a clean area

<u>Maintenance:</u> - inspect, lubricate, fill with hydraulic fluid — monthly

<u>Component Replacement:</u> - replace filter — monthly

8. Mining Boom

<u>Usage:</u> Boom- 24 motions per cycle
Hoist- once per tool change

<u>Wash-down:</u> Required

<u>Maintenance:</u>

- inspect hoist cable	monthly
- inspect and lubricate hoist	6 months
- inspect and adjust cylinders and linkages	per tank
- replace seals	per tank
- lubricate and adjust guide rollers	per tank

<u>Component Replacement:</u> - hoist cable — as required

9. Mining Tools

<u>Usage:</u> 24 per cycle for tool used

<u>Wash-down:</u> Required

<u>Maintenance:</u> - inspect, adjust and lubricate — after each use

<u>Component Replacement:</u> - cylinder and linkages — per tank

10. Tool Change Machine

<u>Usage:</u> One per tool change

<u>Wash-down:</u> Required

<u>Maintenance:</u> - inspect, adjust and lubricate — per tank

Component Replacement: - motor and cylinders — per tank

11. Tool Wash Station

Usage: One per tool change

Wash-down: Not required- It is self washing

Maintenance: -inspect, adjust and lubricate — per tank

Component Replacement: - door seals — per tank

12. Two-Ton Crane

Usage: Occasional-Primary purpose is to move tools between storage racks. Secondary purpose is for general maintenance of System

Wash-down: Required

Maintenance:- inspect hoist cable — 6 months
- lubrication and adjustment — 6 months

Component Replacement: - hoist cable — as required or per tank

13. Two-Ton Monorail Hoist

Usage: Occasional- It is used to maintain and move parts in the maintenance area

Wash-down: Not required

Maintenance: -inspect hoist cable, lubrication and adjustment — 2 months

Component Replacement: -hoist cable — as required or per tank

14. Model 3000 Manipulator

<u>Usage:</u> Occasional- It is used for non-routine remote handling

<u>Wash-down:</u> Required after each operation

<u>Maintenance:</u> - inspect, lubricate and adjust — per tank

<u>Component Replacement:</u> -hand and hook — after each use if contaminated

15. Inter-Cell Doors

<u>Usage:</u> Occasional- They are opened only for non-routine maintenance operations and for movement of System between tanks

<u>Wash-down:</u> Required

<u>Maintenance:</u> - inspect, lubricate, adjust and replace seals — per tank

<u>Component Replacement:</u> -general

16. Controls and Instrumentation

<u>Usage:</u> Usage varies from occasional to very repetitive, depending upon the machine

<u>Wash-down:</u> Not required

<u>Maintenance:</u> Adjustments to amplifiers, etc., are made whenever servo potentiometers are replaced

<u>Component Replacement:</u> All control operators, displays, etc. — as required

17. Shipping and Sealing Containers

<u>Usage:</u> One each per cycle

<u>Wash-down:</u> Required

<u>Maintenance:</u>	-cover seal inspection	per cycle
	-mechanism inspection	per cycle
<u>Component Replacement:</u>	- cover seals	10 cycles

18. Transporters

<u>Usage:</u> Once per tank

<u>Wash-down:</u> Not required

<u>Maintenance:</u>	-start-up, and inspection	6 months
	-lubrication	per tank
<u>Component Replacement:</u>	-filters and battery	per tank

19. Ventilation Unit

<u>Usage:</u> Continuous

<u>Wash-down:</u> Not required-contaminated filters -and other components require special handling

<u>Maintenance:</u>	-lubrication, inspection and adjustment	monthly
	-diesel engine/generator start-up, inspection and lubrication	monthly
<u>Component Replacement:</u>	- air filters	as required

20. TV Unit

<u>Usage:</u> Continuous

<u>Wash-down:</u> Not required

<u>Maintenance:</u>	-lubrication and adjustment	monthly
<u>Component Replacement:</u>	-TV camera and lights	as required
	-hoist and electrical cables	2-3 years

21. General Component Replacement

During system shut down between tanks, it is recommended that the following components throughout the system be replaced.

- limit switches
- position encoders and potentiometers
- hydraulic hoses
- hydraulic valves

At intervals of 2 to 3 years, it is recommended that the following components throughout the system be replaced.

- motors, gear boxes and drives
- bearings
- hydraulic cylinders
- movable electrical cables
- pumps

Operation of the Prototype Retrieval System will establish the validity of the above maintenance and component replacement schedules. Means are provided for accomplishing both more frequently if necessary.

Adequate supply of spare parts and replacement components should be kept available on the waste retriever or in a support warehouse on the Hanford Reservation. Depending on the degree of contamination and the cost of each item, replaced parts and components can be repaired for re-use or disposed of.

24.0 PERSONNEL REQUIREMENTS

Several categories of personnel will be required in the operation of the Prototype Waste Retrieval System. The categories and the number of people involved in each will depend on the development program followed in completing the Prototype System, the organization which administers the operation of the System, the operating shift schedules and any local labor regulations.

The personnel requirement estimates are based on the following considerations and assumptions:

a) No design, development or field erection is included. These efforts will depend on the schedule and sequence of the development program which is followed, the facilities available for testing and refining the System and the resolution of any development problems necessary to demonstrate proper operation of the System.

b) The organization which administers operation of the System provides normal staff function support.

c) The System is operated two eight-hour shifts per day.

d) Special procedures and labor regulations pertaining to the Hanford Reservation have not been included.

The categories of personnel involved in the operation of the Prototype System include:

- Operating Personnel

  It is estimated that three or four people per shift will be required to operate the System. Two will be engaged in the direct control of the operations and would be seated at the control consoles in the trailer control center. The other person (or two) would provide shift supervision, record keeping, and health physics monitoring, as well as serving as a back-up control operator.

- Maintenance Personnel

  It is estimated that one trained maintenance person will be required per shift.

  On a two shift per day basis, the third shift could be used for major maintenance. The requirement for a continuous third shift maintenance crew will depend upon operating experience with the system. It is believed that periodic maintenance of this type will be sufficient.

- Material Transport

  It is recommended that two transport tractor/trailers be used for each shift. This would involve two drivers per shift.

- Moving The System Between Tanks

  This will be a periodic operation, occuring when a given waste tank has been emptied and the System is moved to the next tank. It includes shutting down the System, securing it for movement, making the move and preparing it for operation on the next tank.

  It is estimated that six people, in addition to those normally assigned to the System will be required for a period of two weeks.

- Support Functions and Personnel

  It is assumed that supporting functions and personnel will be available through the organization which administers operation of the System. These include:

  - security
  - normal trucking and transportation
  - administration, accounting, personnel, clerical, etc.

25.0 SYSTEM START-UP AND MOVING

25.1 START-UP OPERATIONS

Once the waste retriever has been moved into position over a tank, the operations summarized below will have to be performed to render the retrieval system operational.

a. Connect electric power, communication lines, and water to the waste retriever.
b. Move in the control center trailer and connect interconnecting cables to the waste retriever.
c. Move in and connect the ventilation unit to its riser. Start up the unit.
d. Remove the covers from the two 42-inch risers and extend the sealing boots down to seal around the risers.
e. Remove the covers from risers and install and check out viewing and lighting equipment.
f. Release brakes and stops on overhead cranes and hoists and run through checkout procedures.
g. Start up hydraulic power units and perform checkout procedures.
h. Withdraw the mining boom from its storage position and raise to point where a mining tool can be attached. Perform checkout procedures on mining boom during this operation.
i. Close the door between the filling room and the mining boom room.
j. Perform checkout procedures for the tool change machine.
k. Perform checkout procedures for the tool wash down station and tool maintenance cart.
l. Release stops on the material elevator and perform checkout operations for the elevator.

m. Perform checkout procedures for the shipcon lid handling machine in filling room.
n. Perform checkout procedures for the turntable and air locks.
o. Move in three shipcons and one sealcon: one shipcon to be at the filling station and a second to be at the pre-air lock position on the turntable. The third shipcon is to be in its sealcon, with the sealcon lid removed.
p. Select the appropriate mining tool and mount it on the mining boom using the tool change machine.
q. Open the floor cover and lower the mining boom into the tank and maneuver into position to commence operations.
r. Open the floor cover and lower the material elevator into the tank.

The system is now ready for retrieval operations to commence.

It is estimated that the above start-up operations can be accomplished in one week.

25.2 PRE-MOVING PREPARATION AND MOVING

When retrieval operations have been completed on a tank, it will be necessary to perform a series of operations in preparation for moving the system to the next tank. These operations are summarized below.

a. Remove all shipcons and sealcons from the system and retain them at the processing plant.
b. Retract the mining boom, close the floor cover and carefully wash down the telescoping tubes and boom.
c. Remove and wash down the last used mining tool and store it on a rack.
d. Wash down the maintenance room.
e. Retract the material elevator, close the floor cover and carefully wash down the bucket and telescoping tubes.

f. Wash down the filling room and shipping room, including the turntable and air locks.
g. Move in a set of shipping containers and pump all wash water into the shipcon and ship to the processing plant.
h. Lower the material elevator to the storage position on the floor and set position stops.
i. Open the door between the filling room and the mining boom room and lower and extend the mining boom horizontally through the door to its storage position on the floor.
j. Set the brakes and stops on the overhead cranes, hoist, and crane passage doors.
k. Store all equipment and supplies in the maintenance room areas.
l. Remove all TV viewing and lighting units from tank risers and seal the risers.
m. Disconnect and retract sealing boot from the two 42-inch risers and seal the risers.
n. Shut down the ventilation unit and disconnect from its tank riser.
o. Move the ventilation unit and its auxiliary power unit away from the site.
p. Disconnect inter-connecting cables between control center trailer and waste retriever and move the trailer away from the site.
q. Disconnect electric power and water lines from waste retriever.
r. Set up the guide-wires for use in guiding the waste retriever to the next tank.

The system is now ready to be moved to the next tank. It is estimated the above pre-moving preparations can be accomplished in one week.

The Prototype Retrieval System transporters have a travel speed of 3 feet per minute giving a time of 34 minutes to travel the distance of 102 feet between tanks. Including the maneuvering and final positioning required, it is estimated that the move between tanks can be accomplished in one day.

25.3 PLANNING FOR MOVING

Various aspects of the ground surface conditions existing at the tank farms will require that certain planning and ground preparations be made prior to moving the waste retriever around the tank farm. Also, similar planning will be necessary for moving cross-country between tank farms. The general requirements for site preparation are discussed in Section 28.0. Three aspects of tank farm terrain conditions which will require planning and action more specifically related to the actual moving operation are:

1) general slope of the overall surface which will require action for leveling the retriever over a tank;
2) ground contours at perimeter of farms which will require planning of the path to follow in moving from tank to tank; and
3) deep, wide caissons within farms which will have to be negotiated in some manner.

To provide for cascading overflow from one row of tanks to the next, there is a one-foot drop between adjacent rows. As a consequence, the ground surface has a grade of approximately one per cent. In order to level the waste retriever, it will be necessary to prepare low earthen pads where the transporters on the low sides will stand. The three transporter areas should be level to within about two inches.

At some tank farms, such as the SX farm, the ground slopes away rather steeply along some sides. When maneuvering the waste retriever from one row of tanks to the next it will be necessary to go beyond the last tank in order to turn the retriever in preparation for moving down the next row. In some cases, in order to avoid the steep slope, it will be necessary to back up after completing a row and then maneuver into position for the next row. Consequently, the complete path to be followed for working a given tank farm should be carefully planned in advance.

Deep caissons such as those for the leak detection system at the SX farm are too wide (12 feet) for a transporter to negotiate. The problem created by the presence of these caissons has not been fully evaluated. It may be possible to maneuver around them if the caisson walls can withstand the lateral ground pressure created by near passage of a transporter. However, it may be necessary to fill in the caissons before operating on the tank farm.

Relative to moving the retriever between tank farms, the required width of clear path can be minimized by orienting the main structure in line with the direction of travel. It may also prove advantageous to provide special short T-arms which bring the outboard transporters inward, thus reducing the overall width for cross-country moving.

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26.0 SAFETY PROVISIONS

The Prototype Waste Retrieval System conceptual design includes provisions for assuring that it can be operated in a manner which is safe for personnel and the environment as well as for the equipment.

Among the safety features considered in the conceptual design are:

- Fire Protection

  The Prototype Retrieval System contains a minimum amount of flammable materials. The basic structure and equipment are metal. No solvents or flammable gases are used. Hydraulic fluid used to actuate the mining boom, elevator and other equipment is of a non-flammable type.

  Fuel for the diesel generator, used as a standby power source for the air handling system, is stored in a tank which is isolated from other structures.

  Detectors in the ventilation unit preclude the possible build-up of hydrogen.

- Radiation Protection

  The conceptual design includes provisions to minimize both the amount of radiation exposure of operating personnel and the release of radioactive materials to the environment.

  Operating areas which contain radioactive materials are adequately shielded. Shielded interchange locks are used to maintain shielding integrity as materials are moved into and out of shielded areas.

  All radioactive materials removed from shielded operating areas are contained in shielded, sealed and washed containers. These shipping containers are placed inside a sealing container prior to shipment to provide a double assurance against release of radiation.

  A 10-foot wide low boy trailer, is used to transport the containers. A governor speed-controlled truck and a dedicated road will be used to minimize the possibility of an accident during transit.

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The waste storage tank and the operating areas of the waste retriever are maintained at a slight negative gage pressure to assure that the air flow will be into rather than out of the system. Air locks are provided for all operating areas, to maintain the negative gage pressure. All effluent air passes through an air handling system which contains adequate filters. A standby diesel generator provides power for the air system in the event of a main power failure. The radiation level of effluent air is monitored.

The Prototype Retrieval System is designed for remote operation. The central control station is located in a trailer separated from the main structure. This separation minimizes the radiation levels to which operating personnel are exposed.

Washdown and drying stations are provided for the mining boom, boom tools, and shipping containers to assure that they are sufficiently clean before maintenance or shipping.

A personnel change room equipped with a radiation monitor and a shower is provided adjacent to the maintenance area.

Detection equipment is located throughout the Prototype Retrieval System to assure that radiation levels remain at proper levels.

- Equipment Operation

Equipment used in the System is designed to be fail-safe and reliable. A minicomputer provides automatic control for repetitive functions. Human engineered controls provide easy and safe operations. Interlocks on each item of equipment and between their interface functions prevent misoperation.

Equipment operations are monitored by television, both in the storage tank and the operating areas of the system. Shielded viewing windows are included to allow direct viewing of the operating areas of the system.

- Structural Design

The Prototype Retrieval System conceptual design has taken into consideration, wind loads, snow loads, seismic events and temperatures which,according to the Uniform Building Code, pertain to the Hanford Reservation area.

- General Safety Provisions

  The Prototype Retrieval System will be lighted to allow 24 hour per day operation.

  Heating and cooling are provided for safe conditions for personnel and equipment.

  Normal plant safety considerations such as the use of hand rails, safety ladders, grounded electrical circuits and connections, obstacle-free walkways and suitable safe lifting equipment are provided.

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27.0 COST EFFECTIVENESS

In arriving at a functional and safe Prototype Waste Retrieval System, cost effectiveness also has been considered throughout the conceptual design.

Cost effectiveness judgements relating to the various parts of the System were not made on a rigorous financial trade-off basis. Because the Prototype Retrieval System is only part of the overall defense waste program, and other major considerations such as the waste processing plant and its related costs are not fully defined, it is not possible to make definitive cost-value comparisons.

The approach to cost effectiveness in the conceptual design has been to reasonably assure a continuous supply of waste material to the processing plant, thus utilizing its capital investment and operating costs in an effective manner, and to make reasonable trade-offs in the Prototype Retrieval System itself, thus providing a reliable system at the lowest related cost.

Some examples of the cost effectiveness considerations in the Prototype Retrieval System conceptual design are:

a. Shipping containers are as large as can be handled on a practical and safe basis.

   This minimizes the number of containers required; minimizes the cycle time per unit volume of waste material shipped; minimizes capping, cleaning, handling and transporting containers; and provides a maximum delivery rate to the processing plant.

b. A production line filling operation using a rotary table is used.

   This allows the operations involved in filling, capping, cleaning and handling to be done in parallel with each other to provide a faster cycle time per container and a resulting increased rate of shipment of waste material as compared to operations performed in series.

c. The amount of shielding required for safe operation has been minimized.

The shipping containers are shielded, eliminating the need for shielding in the shipping area, truck and processing plant receiving area.

The container filling area where exposed waste material is handled has been isolated so that only this area needs substantial shielding.

A reduction in shielding is important in the design of the Prototype Retrieval System since shielding is a major weight and cost factor.

d. Provisions have been included for dealing with abnormal situations which may occur.

Access doors between the operating areas allow the overhead cranes to be used in areas beyond their normal coverage, to allow any abnormal conditions to be corrected in a safe and fast manner. Also, the remotely-controlled general-purpose manipulator can move between rooms.

e. A separate shipping and receiving area is provided for handling non-contaminated items such as spare parts and supplies for servicing the equipment.

This allows the waste handling processes to proceed without the interruption which would result from moving these items through the shielded area if they were handlied at the loading dock for waste material.

f. Human-engineered controls based on a minicomputer provide efficient, automatic operation of the sub systems of the Prototype Retrieval System.

This assures a maximum, continuous rate of waste retrieval with the minimum number of operating personnel.

g. A very important cost effective feature included in the design is the system mobility.

The mobility which enables the waste retriever to be moved as a complete unit from tank to tank minimizes the down time between tanks and thus maximizing the availability of the System and the delivery of material to the processing plant.

28.0 SITE PREPARATION

The Waste Retrieval System is designed so as to require a minimum of special site preparation. Conditions prevailing at the site at the time retrieval operations are to commence will also bear on the amount of work to be done before the system can be placed into operation. The essential site preparation requirements are:

a) For tanks which are not already so fitted, install two 42-inch diameter risers; one at the center for the mining boom and and other at a radius of 20 feet 9 inches to accommodate the material elevator.

b) Clear the ground of all obstacles (with the exception of tank risers which can extend 12 inches above ground level).

c) Grade the terrain so as to provide an even surface for transporters and the waste material truck to move over.

d) Grade 3 areas where the system transporters will be located such that they are level with each other.

e) Run in 3-phase, 220 volt, 60-cycle AC power.

f) Run in a telephone communication line.

g) Run in a water supply line.

h) Move in a sanitary toilet facility (probably a portable type).

i) Survey in a guide system for the purpose of accurately positioning the main structure over the tank risers when the waste retriever is being moved from one tank to the next.

28.1 INSTALLATION OF RISERS

The retrieval system is designed to work through two 42-inch risers, one riser to be at the tank center and the second at a radius of 20 feet 9 inches. Of the tanks now in existence at Hanford, the following are fitted with the above risers:

12	BY Tanks
18	TX Tanks
30	Total

All of these tanks have the required two risers located on an east-west line.

Tanks which now have the necessary 42-inch riser at the center, but which will require the installation of a second at the 20 foot 9 inch radius are:

6	A Tanks
15	SX Tanks
6	TY Tanks
12	S Tanks
39	Total

The added riser should be oriented as follows:

A	Tanks - On N-S line
SX	Tanks - On E-W line
TY	Tanks - On N-S line
S	Tanks - On E-W line

The above riser orientation will facilitate movement of the retrieval system from tank to tank.

All of the tanks not listed above have neither the central riser nor one at 20 feet 9 inches radius. Sixteen of these are the smaller (55,000 gallons) B, C, T, and U tanks which are not within the scope of the present effort. Nineteen are the double shell tanks which are being deferred for later consideration. This leaves 64 tanks which will require the installation of two 42-inch risers.

28.2 REMOVAL OF OBSTACLES

The main structure of the waste retriever has a nominal ground clearance of 18 inches. In order that the retriever may be moved from tank to tank without raising it any higher, it is recommended that all obstacles on the ground be removed. A maximum allowable height of 12 inches is recommended to provide a safety factor.

Removal of obstacles also includes overhead wires, pipe lines, poles, fences, etc., which will otherwise interfere with the operation of moving from tank to tank.

28.3 GRADING

The track transporters to be used for moving the system are capable of going over unpaved or non-prepared surfaces. The unit ground loading of the tracks will be quite low (14.5 psi). However, the ground surface should be graded smooth to minimize unevenness and clear off any large rocks or debris.

The areas to be graded will be between tanks, not over the tank domes. Graded strips should run the length of the tank farm. Graded areas should be provided at the ends of the farm to allow the retrieval system to be maneuvered from one row of tanks to the next.

Special grading will be required at the areas where the system transporters are located at each tank. These areas should be level with each other within an inch or two, in order to level the waste retriever.

A suitable roadway must also be prepared over which the waste transport truck will move. This includes the roads in and about the tank farm as well as the road to the processing plant.

In establishing travel areas within the tank farm, it will be necessary to keep heavily-loaded vehicles off the overburden covering the tank dome. For example, temporary fencing could be erected to encircle the tanks.

28.4 UTILITIES

Standard utilities such as electric power, telephone, water, and toilet facilities should be provided at the site. In planning the installation of power, telephone and water supply lines; consideration should be given to the periodic relocation of the main structure as it is moved from tank to tank.

28.5 GUIDE SYSTEM

As discussed in Section 18.0, there is a requirement for a reference network to be used in accurately positioning the retrieval system over the two risers. It will not be practical to install a complete system of guide wires at the time of site preparation. There will be a lot of movement of vehicles and personnel over the tank farm area and the guide wire system would be subject to damage. The initial survey work should establish a sufficient number of reference points which can be protected and from which the required quide wires can be set up quickly at the time of relocating the retrieval structure.

29.0 PROCESSING PLANT CONTAINER HANDLING

The interface between the Prototype Waste Retrieval System and the processing plant to be located on the Hanford Reservation are the areas of the processing plant which receive, empty, wash and ship the shipping and sealing containers.

The basic requirements for these areas of the processing plant are similar to those of the Prototype Retrieval System.

The facilities include:

- Unshielded shipping and receiving area

  a. overhead 20-ton crane

  b. sealing container wash station with means of transporting opened sealing containers and their covers into and out of the wash station.

  c. storage area for spare shipping and sealing containers.

- Air and shielding lock between the unshielded and shielded areas including a means of transporting shipping containers between the unshielded and shielded areas.

- Shielded Area

  a. shipping container cover removal and replacement machine

  b. shipping container emptying machine, including scrap segregation

  c. shipping container wash station

  d. means of moving shipping containers between operations

The design of the above areas of the processing plant will depend to a large extent upon the overall plant process and layout.

Conceptually, the handling of containers will be the same as that used at the Prototype Retrieval System.

Filled shipping containers inside of sealing containers will arrive at the processing plant by trailer.

The overhead 20-ton crane will move the containers from the trailer to an unshielded receiving area, remove the cover from the sealing container and move the filled shipping container to a transport device.

The transport device will carry the shipping container through an air and shielding lock into the shielded emptying area. The shipping container cover will be removed and the container emptied. This probably will require a device which clamps the base of the opened shipping container and tips it to dump the contents into a receiving tank or hopper.

All surfaces of the shipping container and its cover will be washed and the cover placed on the container. It would appear desireable to wash the external surfaces of the shipping container again as it passes through the air and shielding lock into the unshielded area.

The sealing container and its cover should be washed in the unshielded area prior to placing the washed shipping container inside.

After the sealing container cover is replaced, the containers are ready for loading onto the trailer for return to the Prototype Retrieval System.

The processing plant will be a fixed facility, as opposed to the mobile Prototype Retrieval System, and therefore should be equipped for functions which would be difficult to incorporate in the Retrieval System. The processing plant should have an area for storing extra shipping and sealing containers and replacing cover gaskets. Scrap segregation should take place at the processing plant. A special shielded area equipped with a manipulator should be considered for removing miscellaneous scrap items (such as rocks, metal and glass) from the shipping containers and placing them in appropriate containers for disposal. Because the use of water at the Prototype Retrieval System is restricted, the shipping and sealing containers should be washed thoroughly at the processing plant.

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APPENDIX

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APPENDIX A

ALTERNATE DESIGNS

The following section gives a summary of alternate designs which were considered in arriving at the Prototype Retrieval System conceptual design. The major alternatives and their advantages and disadvantages are discussed.

A.1 ALTERNATE CONTAINER DESIGNS

The container configuration described in Section 11.0 uses a shielded shipping container (shipcon) having a capacity of 96 cubic feet, a sealing container (sealcon) which contains the shipcon, and a shock absorbing mounting enclosure on the transport trailer. One full load is transported to the processing plant and empty, cleaned containers are returned to the tank site.

Considerations relative to the shipping containers include:

- the volume of the shipcon
- the number of containers carried per trailer
- the placement of container shielding
- the placement of protective energy absorbing means

Alternate container configurations which were considered are:

a) Fifty-five gallon drums
These are commercially available at low cost and are used in some waste processes. They were dropped from consideration because of their small volume (7.35 cu. ft.). One elevator load contains 24 cu. ft. The use of 55-gallon drums would require a smaller elevator and would involve many capping, cleaning and handling operations, with too short a cycle time.

b) 150-Cubic Foot Container

A 150-cu. ft. shipcon was considered in the initial study and report. The initial study had primary emphasis on the in-tank handling and viewing equipment. The other parts of the system, including shipping containers were studied only to the extent that the feasibility of the overall system could be shown. The 150-cu. ft. shipcon would contain 6 elevator loads and was selected on the basis that the largest possible volume would be best. Further consideration indicated that this container was excessively large from the standpoints of total weight and size of load required to be handled by the truck trailer and by the equipment in the shipping room.

c) 75-Cubic Foot Container

A 75-cu. ft. container was investigated on the basis that two containers could be carried on each trailer load. Each loaded container plus enclosure on trailer is estimated to weigh 31,500 lbs. with a resulting load on the trailer of 63,000 lbs. This load is considered to be excessive.

d) Unshielded Shipcons

The original design used unshielded shipcons and sealcons with the shielding being carried on the transport trailer. This had the advantage of not having to lift and load the shielding weight. Because the total shielding weight required is less if it is placed around the shipcon and this arrangement affords the best means of minimizing radiation exposure (without primary reliance on administrative control), a shielded shipcon is recommended. Using a shielded shipcon also reduces the amount of shielding required in the waste retriever walls since only the filling room needs to be heavily shielded and the shipping room needs no shielding.

A.2 MINING BOOM

The conceptual design uses a hydraulically actuated boom having multiple sections joined by pivot pins. The boom is mounted on a telescoping tube to allow the boom to be inserted into the waste tank. A boom rotate drive is incorporated in the mounting. The rotate drive and articulations of the boom allow it to reach all locations in a tank, to work around tank obstructions, to be inserted into and withdrawn from a tank filled to maximum capacity, and to remove an entire stratum of material before proceeding to the next level. It operates through a 42-inch diameter riser.

Alternate mining boom arrangements considered are:

a) Telescoping Boom

This general type of boom has multiple sections which telescope within each other to provide an extension/retraction motion. This motion often is combined with a vertical pivot and a rotate motion.

It was not possible to arrive at a telescoping boom arrangement which would meet the basic requirements of being able to reach all portions of the tank, work around tank obstructions, and be capable of being placed in a filled tank. A telescoping boom does not meet any of these requirements. An examination of the possibility of working through a 12-foot diameter tank opening, rather than a 42-inch diameter riser did not solve the problem.

A lesser but important consideration is the difficulty in handling hydraulic and electrical lines on a telescoping boom.

b) Replaceable Carriage Boom

An interim consideration in arriving at the boom used in the conceptual design was a boom with multiple sections joined by pivots which allowed the boom to be placed in a filled tank through a central 42-inch diameter riser. A tool carrying carriage which rides on the top of the boom would be lowered through a second 42-inch diameter riser and remotely engaged to the boom. The carriage would be removed for tool changing.

This arrangement complicates the hydraulic and electrical connection problem, does not provide means for easy tool changing and does not work well around obstructions. It also would require that another 42-inch riser be installed in waste tanks which are not now so equipped.

A.3 MATERIAL ELEVATOR

The conceptual design uses an elevator bucket which is pivoted from vertical to a position over a shipcon and the bucket bottom door opened to discharge the material. A waste water spray, mounted over the elevator bucket washes it out during each discharge.

An alternate method of emptying the elevator bucket used a hydraulic rotary actuator to dump the bucket, so that the material would be discharged through the open top of the bucket.

This method presents a problem of containing the spillage of material during dumping and would require the use of movable baffles. It also requires considerably more headroom in the filling room and a resulting increase in shielding weight.

The conceptual design uses a telescoping tube to provide vertical travel.

An alternative consideration was to have fixed guide rails extending into the tank. This has the disadvantages of the guide rails being an obstruction around which the boom must work; of requiring assembly and disassembly each time the system is moved from tank to tank and of not being able to enter a filled tank and follow the changing waste material level as material is removed from the tank.

A.4 MAIN STRUCTURE

Several configurations of the Prototype Waste Retrieval System were considered. The conceptual design uses a T-shaped structure with a tracked transporter located at each of the three ends of the T.

Alternate configurations include:

a) Non-mobile Structure
The first design considered a structure which was supported by leveling pads resting on the ground. Moving the system between tanks would involve partial disassembly, moving sub-sections by a truck-mounted crane and reassembling the system.

b) Cross-shaped Structure
A cross-shaped structure would use four structural sections extending from the tank center to a point beyond the tank perimeter. A tracked transporter would be located at each of the four ends of the cross.

The basic problem with this arrangement is that transporters must pass over the tank in moving the system from one tank to another, unless a complicated moving pattern involving rotating the structure while it is translated is used.

Extending the four legs on a diagonal so that the transporters clear the tank involves an excessively long structure.

A four-point suspension presents difficulties, particularly during movement from one tank to another, because of the large torsional loads which can be imposed on the structure if the four points are not kept level at all times. This would involve extensive grading and leveling in the waste tank area.

c) H-Shaped Structure
The H-shaped structure, with a transporter at each end of the H,has the advantage of not imposing loads on the tank dome during movement between tanks and allowing the system to move along either rows or columns of tanks. To accomplish this the square formed by the four transporters would have to be approximately 100 feet on each side.

The H-shaped structure involves a larger structure and has the problem of excessive loads imposed by four support points.

A-5 SYSTEM TRANSPORTERS

The conceptual design uses three powered, tracked vehicles to support the system and move it between tanks.

Alternate considerations include:

a) Multiple Tire Supports
This approach would use multiple tires combined into a chassis at each of the system support points. Motive power would be supplied by a separate tractor or winch.

It was discarded because of the large number of wheels required to meet the ground loading requirements.

b) Unpowered Tracked Supports
This approach is the same as that used in the conceptual design except that the motive power required to move the system between tanks would be provided by a separate tractor or winch.

Individually powered units were chosen because of the difficulty in towing and steering unpowered tracked vehicles.

A.6 SHIPPING CONTAINER HANDLING

Several means of moving containers from the trailer into and out of the shipping and receiving room and the filling room were considered.

The functions to be performed are:

- move a sealcon, containing a shipcon from the trailer to the shipping/receiving room.
- remove the sealcon cover.
- move the shipcon into the filling room.
- remove the shipcon cover.
- fill the shipcon.
- replace the shipcon cover.
- wash and dry the filled shipcon.
- move the shipcon to the shipping/receiving room and place inside sealcon.
- replace the shipcon cover and load onto the trailer.

The means of accomplishing the above functions used in the conceptual design uses a 20-ton overhead crane to handle containers between the trailer and the shipping/receiving room;

a turntable and two combination air-shielding locks, one of which includes a wash/dry station to move containers into and out of the filling room; and a cover handling machine.

Alternate methods considered include:

a) One overhead crane to perform all functions.
   This method puts all functions in series, since they all depend on one crane. This slows down the cycle time and keeps the crane on the critical path at all times. Crane down-time for maintenance or a delay at any function would stop the overall operation.

   Numerous moves and connect/disconnects are required for each cycle. This complicates the operation and control system.

   The use of one crane complicates the problem of maintaining shielding and air lock integrity between the shielded and unshielded areas.

b) One Overhead Crane in the Shipping/Receiving Room and One Overhead Crane in the Filling Room
   This is an improvement over the use of one crane since shipping/receiving and filling room functions can run in parallel.

   All of the operations in the filling room, still depend on one crane and require numerous moves per cycle.

   The problem of maintaining shielding and air lock integrity remains difficult.

c) Track Mounted Transport Cart
This method would replace the turntable used in the conceptual design with a cart to carry shipcons into and out of the filling room. The cart would pass through a single shield and air lock containing a wash and dry station.

This method requires that only one shipcon can be in the cycle at one time. All functions are in series with the resulting increase in cycle time.

A.7 MINING BOOM AND TOOL MAINTENANCE

The conceptual design uses contact maintenance made possible by equipment wash stations which reduce exposures to acceptable levels. Exposure time is minimized by the reliability of the equipment and the use of modular, quick connect/disconnect components.

An alternate method would be to use remote maintenance. This could be accomplished by the use of standard manipulators and special remotely operated maintenance tools and fixtures located in a shielded maintenance area.

Remote maintenance would be more time consuming than contact maintenance and would involve more equipment. However, remote maintenance is an entirely feasible method and can be incorporated into the system should radiation levels in the maintenance area require it.

A.8 CONTROL CENTER

The Prototype Retrieval System conceptual design uses a separate trailer for the control center.

The alternate arrangement considered was to have the control center in the main structure. The advantages of the alternate arrangement are that inter-connecting wiring between the control center and the system equipment would be simpler and the system would be more of an integral unit (the ventilation unit, diesel generator and TV mounts would still be separate units).

The advantages of a separate trailer control center are:

Shielding is not required for the operators because of the separation between the trailer and the radioactive material being handled; the control center does not require space in the main structure or add weight to it; the control center can be assembled and checked out independent of the main system; and it is inherently safer and more comfortable for the system operators.

APPENDIX B

MATERIAL REMOVAL RATE SUMMARY

On the basis of the proposed design parameters with one 24-cubic ft. elevator bucket load per each 18-minute interval, the removal rate is:

$$R_1 = \frac{24 \times 7.48}{\frac{18}{60}} = 598.4 \text{ gallons/hr.}$$

The specified requirement is 500 gallons/hr.

Operating on the average of two 8-hour shifts per day, the retrieval rate is:

$$R_2 = 365 \times 2 \times 8 \times 598.4 = 3.495 \times 10^6 \text{ gallons/yr.}$$

Over a 15-year period the volume of waste material which can be retrieved is:

$$V_{15} = 15 \times 3.495 \times 10^6 = 52.42 \times 10^6 \text{ gallons}$$

The predicted volume of solid waste to be retrieved has been estimated at 36,000,000 gallons.* Thus, the design removal rate of 598.4 gallons/18 minutes provides ample reserve for meeting the program objective of completing the retrieval operation over a 15-year period.

* "Program of the Hanford High-Level Waste Retrieval Task", ARH-LD-144, H.A. Wallskog, ARHCO, Richland, Washington, December, 1976.

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APPENDIX C

ESTIMATED WEIGHTS & C.G. LOCATIONS

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BY M... DATE 3-3-77 SUBJECT APPENDIX C
CHKD. BY........ DATE........ ESTIMATED WEIGHTS & C.G. LOCATIONS

SHEET NO. 1 OF 4
JOB NO. 5024

C-00020

ITEM	W	$w = W/FT$	X_1	X_2	$\bar{X}$
1. MINING BOOM (W/C TOOL)	7,075				53.50
2. MINING BOOM TELESC. TUBES & CARRIAGE	18,196				
3. MINING BOOM TOWER & HOISTING CABLE	13,784				
4. MINING BOOM HYDRAULIC LINES & VALVES	500				
5. MINING BOOM TELESC. TUBE CLAMP	750				
6. MINING BOOM RISER SEAL & FLOOR HATCH	500				
7. MINING BOOM WASHER	100				
8. TOOL - IMPACT HAMMER	1,460				
* TOTAL LOAD AT MINING BOOM LOCATION	42,365				53.50
9. MATERIAL ELEVATOR BUCKET ASS'Y	1,340				32.75
10. 24 CU.FT. WASTE	2,550				
11. ELEVATOR TELESC. TUBES & CARRIAGE	9,359				
12. ELEVATOR TOWER & HOISTING CABLE	8,005				
13. ELEVATOR TOWER SHIELDING	11,266				
14. ELEVATOR HYDRAULICS	300				
15. ELEVATOR RISER SEAL & FLOOR HATCH	500				
16. ELEVATOR TV & LIGHT	70				
* TOTAL LOAD AT ELEVATOR LOCATION	33,390				32.75
17. MINING BOOM HOIST	5,084				59.50
18. MAT'L ELEVATOR HOIST	5,084				38.00
19. NO. 1 HYDRAULIC UNIT	1,920				85.00
20. NO. 2 " "	1,920				85.00
21. NO. 3 " "	1,920				85.00

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BY MAL DATE 3-8-77 SUBJECT APPENDIX C
ESTIMATED WEIGHTS & C.G. LOCATIONS
CHKD. BY .... DATE ....
SHEET NO 2 OF 4
JOB NO. 5004

-00020

ITEM	W	w = W/FT.	X_1	X_2	$\bar{X}$
22. TURNTABLE & CENTER DECK	12,050	803.3	13.0	28.0	20.50
23. SHIPCON, EMPTY	17,030				14.25
24. SHIPCON, FULL	27,210				27.00
25. SHIPCON, FULL	27,210				20.50
26. ENTRANCE AIRLOCK	24,145				20.50
27. WASH STATION	24,345				20.50
28. SEALCON, EMPTY	5,480				5.75
29. SEALCON & SHIPCON, EMPTY	22,510				5.75
30. SHIPCON LID HANDLER	1,500				24.00
31. 20-TON CRANE	11,110				26.00
32. TOOL CHANGE MACHINE	2,200				50.75
33. TOOL - CLAM SHELL	850				37.50
34. " - BACK HOE	725				37.50
35. " - PIPE & ROD SHEAR	900				37.50
36. " - PIPE CUT OFF	1,000				56.50
37. " - WALL CLEANER	1,150				53.00
38. " - GRAPPLE	850				49.25
39. 2-TON CRANE	3,500				49.00
40. TOOL WASH-DOWN STAND RAILS & DRIVE	1,310				65.00
41. MONORAIL HOIST & RAIL	300				65.00
42. TOOL RACKS - SIX @ 145 LB	850				37.50
43. TOOL RACK	145				45.00
44. " "	145				48.00
45. " "	145				51.00
46. " "	145				54.75
47. " "	145				57.75
48. WATER TANK & PUMP	1,000				34.00
49. FLOOR PLATE - SHIPPING	9,155	~~448.8~~	0.0	10.5	5.25
50. " " - TURNTABLE	4,555	224.4	10.5	30.5	20.50
51. " " - FILLING, TOOL STOR., MAINTENANCE & LOCKER ROOMS	15,485	336.6	30.5	76.5	53.50
52. LIVE FLOOR LOAD FOR TOOL MAINT. ROOM & AIR LOCK & LOCKER ROOM	13,700	913.3	61.5	76.5	70.00

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BY mal DATE 3-8-77 SUBJECT APPENDIX C ESTIMATED WEIGHTS & C.G. LOCATIONS

CHKD. BY ____ DATE ____

JOB NO 5004

ARH-C-00020

ITEM	W	$w = W/FT$	X_1	X_2	$\bar{X}$
53. CEILING	4,210	55.0	0	76.5	38.25
54. TOOL - SLURRY PUMP	1,000				46.50
54. END " & FRAMING	2,215				77.50
55. ROOF PANELS	3,980	50.4	-1.5	77.5	38.00
56 ROOF LOAD @ 20 LB/FT²	37,920	480.0	-1.5	77.5	38.00
57. SHIPPING DOOR	4,075				0.00
58. FILLING CELL WALL NO.1	2,830				20.50
59. CELL WALL, NO.1, SHEILDING	19,000				20.50
60. CELL WALL, NO.2	4,965				37.50
61. " " ", SHIELDING	33,200				37.50
62. TOOL RM/MAINT. RM WALL	3,630				61.50
63. " " , SHIELDING	2,770				61.50
64. MAINT. RM/LOCKER RM WALL	3,060				69.75
65. LOCKER RM/AIRLOCK WALL	500	83.3	70.5	76.5	73.50
66. DECK FOR STORAGE LOFT	1,420	233.3	70.5	76.5	73.50
67. LIVE LOAD FOR STORAGE	6,600	1,100.0	70.5	76.5	73.50
68. TOOL WASH CHAMB. FRAME	1,760	270.8	61.75	68.25	65.00
69. " " " SHIELD'G	2,370	364.6	61.75	68.25	65.00
70. EXTERIOR SIDE WALLS - PANELS + FRAMING, 2 SIDES (20-TON CRANE TRAVEL)	10,760	179.3	0.0	30.0	15.0
71. EXTERIOR SIDE WALLS - PANELS + FRAMING, 2 SIDES (OTHER THAN ITEM 70)	14,305	153.8	30.0	76.5	53.25
72. SHIELDING, EXTERIOR SIDE WALLS, FILLING CELL	51,315	3,018.5	20.5	37.5	29.0
73. SHIELDING, EXTERIOR SIDE WALLS, TOOL STORAGE RM.	6,040	251.7	37.5	61.5	49.5
74. 20-TON CRANE PASS. DOOR	1,325				20.5
75. PIPE CUTOFF TOOL-INTERNAL	800				46.0
76. MODEL 3000 MANIPULATOR & BRIDGE	3,500				30.0
77. RAILS, 2-10 CRANE & 3000	2,640				50.0
78. POWER CENTER EQUIP'T	2,500				80.0
79. PERSONNEL CORRIDOR	8,120				43.5
80 POWER CENTER (EMPTY)	3,465				82.8

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BY mal DATE 4-20-77 SUBJECT APPENDIX C ESTMATED WEIGHTS & C.G. LOCATIONS

CHKD. BY ____ DATE ____

SHEET NO 4 OF 4

JOB NO. 5004

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ITEM	W	$w = W/FT$	X_1	X_2	$\bar{X}$
81. T ARMS	57,780				4.67
82. FRAME, MAIN STRUCTURE	136,900				46.28

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APPENDIX D

STATIC ANALYSIS OF MAIN STRUCTURE USING SAGS PLANAR FRAME ANALYSIS

An inconsistency exists in the data as presented. Spans 47, 49, 54, 56, and 58 are subjected to axial compressive forces which can not be supported by the 2-inch rods used in the analysis as the members for these spans. Analysis procedures employed during actual design of the frame structure would treat these members so as to obtain consistent results.

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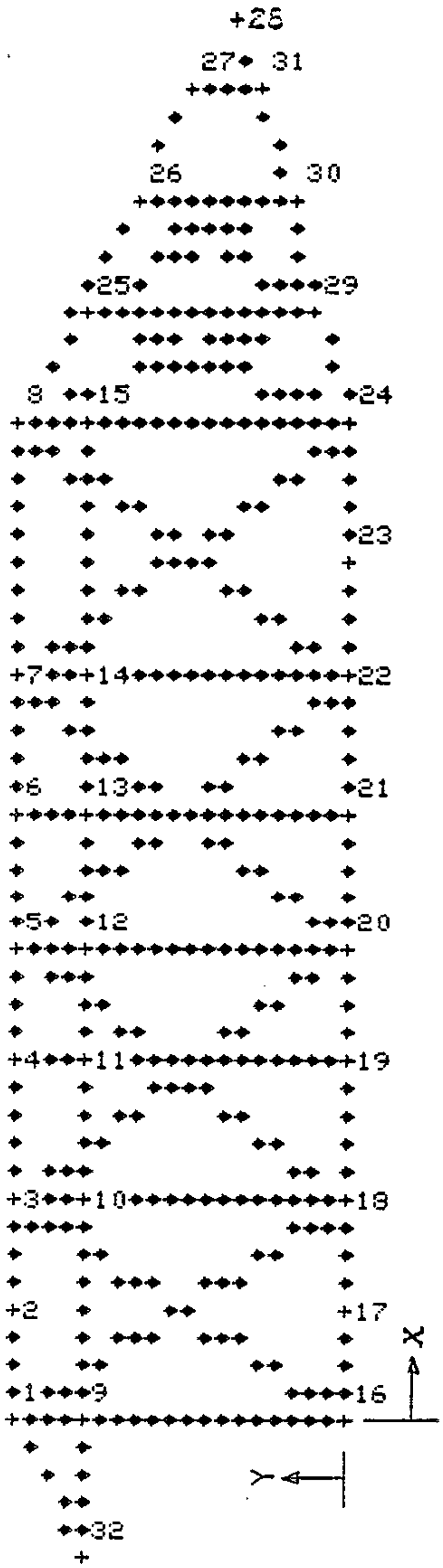

PLOT NO. 1 WASTE RETRIEVAL SYSTEM UNDEFORMED

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STATIC ANALYSIS OF GENERAL STRUCTURES

STRUCTURAL DYNAMICS RESEARCH CORPORATION

WASTE RETRIEVAL SYSTEM

*** PLANAR FRAME ANALYSIS ***

SPAN	LENGTH	FORE END JOINT	AFT END JOINT	MATERIAL CODE	SECTION CODE	ROTATION ANGLE	TEMP.
1	96.00	16	17	1	1		
2	102.00	17	18	1	1		
3	120.00	18	19	1	1		
4	120.00	19	20	1	1		
5	120.00	20	21	1	1		
6	120.00	21	22	1	1		
7	120.00	22	23	1	1		
8	120.00	23	24	1	1		
9	198.00	9	10	1	2		
10	120.00	10	11	1	2		
11	120.00	11	12	1	2		
12	120.00	12	13	1	2		
13	120.00	13	14	1	2		
14	240.00	14	15	1	2		
15	96.00	1	2	1	1		
16	102.00	2	3	1	1		
17	120.00	3	4	1	1		
18	120.00	4	5	1	1		
19	120.00	5	6	1	1		
20	120.00	6	7	1	1		
21	240.00	7	8	1	1		
22	228.00	16	9	1	4		
23	66.00	9	1	1	4		
24	228.00	18	10	1	4		
25	66.00	10	3	1	4		
26	228.00	19	11	1	4		
27	66.00	11	4	1	4		
28	228.00	20	12	1	4		
29	66.00	12	5	1	4		
30	228.00	21	13	1	4		
31	66.00	13	6	1	4		
32	228.00	22	14	1	4		
33	66.00	14	7	1	4		
34	228.00	24	15	1	4		
35	66.00	15	8	1	4		
36	122.63	8	25	1	1		
37	115.38	25	26	1	1		
38	115.38	26	27	1	1		
39	75.67	27	28	1	1		
40	113.08	24	29	1	1		
41	106.36	29	30	1	1		
42	106.36	30	31	1	1		
43	69.76	31	28	1	1		
44	210.00	29	25	1	5		
45	130.90	30	26	1	5		
46	51.80	31	27	1	5		

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STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

SPAN AN	LENGTH	FORE END JOINT	AFT END JOINT	MATERIAL CODE	SECTION CODE	ROTATION ANGLE	TEMP.
7	354.46	16	3	1	3		
8	354.46	1	18	1	3		
9	379.52	18	5	1	3		
0	379.52	3	20	1	3		
1	379.52	20	7	1	3		
2	379.52	5	22	1	3		
3	379.52	22	8	1	3		
4	379.52	7	24	1	3		
5	262.48	24	25	1	3		
6	287.06	8	29	1	3		
7	188.39	29	26	1	3		
8	210.03	25	30	1	3		
9	147.58	32	1	1	6		
0	132.00	32	9	1	2		

JOINT COORDINATES

INT	X	Y	Z
1	.000	294.000	
2	96.000	294.000	
3	198.000	294.000	
4	318.000	294.000	
5	438.000	294.000	
6	558.000	294.000	
7	678.000	294.000	
8	918.000	294.000	
9	.000	228.000	
10	198.000	228.000	
11	318.000	228.000	
12	438.000	228.000	
13	558.000	228.000	
14	678.000	228.000	
15	918.000	228.000	
16	.000	.000	
17	96.000	.000	
18	198.000	.000	
19	318.000	.000	
20	438.000	.000	
21	558.000	.000	
22	678.000	.000	
23	798.000	.000	
24	918.000	.000	
25	1027.400	238.600	
26	1130.300	186.400	
27	1233.200	134.200	
28	1300.700	100.000	
29	1027.400	28.600	
30	1130.300	55.500	
31	1233.200	82.400	
32	-132.000	228.000	

STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

MATERIAL PROPERTIES

CODE	E	G	DENSITY	THERMAL COEFFICIENT
1	29.0E+06	12.0E+06	.284	

CROSS-SECTION PROPERTIES

CODE	AREA	MOMENT OF INERTIA	SHEAR RATIO
1	3.54E+01	3.65E+03	2.90
2	2.47E+01	2.37E+03	2.46
3	3.14E+00	1.96E-01	1.11
4	9.19E+00	8.81E+01	2.32
5	6.48E+00	5.84E+01	2.03
6	7.35E+00	1.44E+02	1.72

DISTANCE TO OUTER FIBER

CODE	Y	Z	R
1	12.000	1.000	1.000
2	12.000	1.000	1.000
3	1.000	1.000	1.000
4	4.000	1.000	1.000
5	4.000	1.000	1.000
6	6.000	1.000	1.000

SPECIFIED RESTRAINTS

JOINT	DIR	TYPE	VALUE
16		SOCKET	
28	Y	LINEAR	

STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

-0-00020

ADING NO. 1: DEAD LOADING

APPLIED FORCES

INT	DIR	TYPE	VALUE
1	Y	FORCE	-4.63E+03
2	Y	FORCE	-3.12E+03
3	Y	FORCE	-3.32E+03
4	Y	FORCE	-4.38E+03
5	Y	FORCE	-7.77E+03
6	Y	FORCE	-4.44E+03
7	Y	FORCE	-8.64E+03
8	Y	FORCE	-3.93E+03
9	Y	FORCE	-1.11E+04
10	Y	FORCE	-9.77E+02
11	Y	FORCE	-1.76E+04
12	Y	FORCE	-1.43E+04
13	Y	FORCE	-1.49E+04
14	Y	FORCE	-2.08E+04
15	Y	FORCE	-4.60E+02
17	Y	FORCE	-2.74E+04
18	Y	FORCE	-6.43E+04
19	Y	FORCE	-5.33E+04
20	Y	FORCE	-3.34E+04
21	Y	FORCE	-1.20E+04
22	Y	FORCE	-1.04E+04
23	Y	FORCE	-1.28E+04
24	Y	FORCE	-8.71E+03
25	Y	FORCE	-3.40E+02
26	Y	FORCE	-1.85E+02
27	Y	FORCE	-8.00E+01
29	Y	FORCE	-3.40E+02
30	Y	FORCE	-1.85E+02
31	Y	FORCE	-8.00E+01

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STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

LOADING NO. 2: WIND AND DEAD LOADING

APPLIED FORCES

JOINT	DIR	TYPE	VALUE
1	Y	FORCE	-4.63E+03
2	Y	FORCE	-3.12E+03
3	Y	FORCE	-3.32E+03
4	Y	FORCE	-4.38E+03
5	Y	FORCE	-7.77E+03
6	Y	FORCE	-4.44E+03
7	Y	FORCE	-8.64E+03
8	Y	FORCE	-3.93E+03
9	Y	FORCE	-1.11E+04
10	Y	FORCE	-9.77E+02
11	Y	FORCE	-2.06E+04
12	Y	FORCE	-1.75E+04
13	Y	FORCE	-2.05E+04
14	Y	FORCE	-3.02E+04
15	Y	FORCE	-4.60E+02
17	Y	FORCE	-2.74E+04
18	Y	FORCE	-6.43E+04
19	Y	FORCE	-5.33E+04
20	Y	FORCE	-3.34E+04
21	Y	FORCE	-1.20E+04
22	Y	FORCE	-1.04E+04
23	Y	FORCE	-1.28E+04
24	Y	FORCE	-8.71E+03
25	Y	FORCE	-3.40E+02
26	Y	FORCE	-1.85E+02
27	Y	FORCE	-8.00E+01
29	Y	FORCE	-3.40E+02
30	Y	FORCE	-1.85E+02
31	Y	FORCE	-8.00E+01

WEIGHT LOADING IN THE -Y DIRECTION

STRUCTURE WEIGHT = 44024.40

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STATIC ANALYSIS OF GENERAL STRUCTURES

STRUCTURAL DYNAMICS RESEARCH CORPORATION

WASTE RETRIEVAL SYSTEM

• LOADING NO. 1: DEAD LOADING

JOINT DISPLACEMENTS

INT	X	Y	ROTATION
1	7.526E-02	-1.373E-01	-2.823E-03
2	6.767E-02	-4.150E-01	-2.842E-03
3	5.960E-02	-6.956E-01	-2.656E-03
4	3.513E-02	-9.831E-01	-1.509E-03
5	1.042E-02	-1.057E+00	-2.460E-04
6	-1.761E-02	-1.052E+00	5.211E-04
7	-4.508E-02	-9.208E-01	1.479E-03
8	-9.010E-02	-4.964E-01	1.270E-03
9	-4.715E-02	-1.115E-01	-2.290E-03
0	-4.369E-02	-7.058E-01	-2.791E-03
1	-4.070E-02	-9.895E-01	-1.432E-03
2	-3.755E-02	-1.063E+00	-2.229E-04
3	-3.497E-02	-1.054E+00	5.358E-04
4	-3.319E-02	-9.253E-01	1.328E-03
5	-3.201E-02	-5.017E-01	1.797E-03
6	.000E+00	.000E+00	-4.397E-03
7	7.489E-03	-4.189E-01	-3.794E-03
8	1.545E-02	-7.376E-01	-2.739E-03
9	3.725E-02	-1.011E+00	-1.309E-03
0	5.917E-02	-1.062E+00	-1.018E-04
1	8.539E-02	-1.051E+00	5.880E-04
2	1.116E-01	-9.191E-01	1.339E-03
3	1.335E-01	-7.377E-01	1.758E-03
4	1.553E-01	-5.162E-01	1.497E-03
5	-5.888E-02	-3.895E-01	8.718E-04
6	-2.230E-02	-2.755E-01	1.232E-03
7	3.602E-02	-1.187E-01	1.587E-03
8	8.242E-02	.000E+00	1.704E-03
9	1.400E-01	-3.891E-01	1.020E-03
0	1.268E-01	-2.746E-01	1.262E-03
.	1.025E-01	-1.184E-01	1.624E-03
2	-4.904E-02	1.287E-01	-1.651E-03

JOINT REACTIONS

INT	F(X)	F(Y)	MOMENT
6	1.400E-08	2.661E+05	.000E+00
8	.000E+00	1.219E+05	.000E+00

9 2 1 2 5 0 1 0 3 6 1

STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

SUMMATION OF FORCES AT JOINTS

JOINT: 1

SPAN	F(X)	F(Y)	MOMENT
15	8.122E+04	4.759E+03	2.344E+05
23	-4.300E+03	-1.042E+05	-1.625E+05
48	-6.666E+04	9.913E+04	5.051E+03
59	-1.026E+04	-4.365E+03	-7.689E+04
	---------	---------	---------
	-7.003E-11	-4.630E+03	6.854E-09

JOINT: 2

SPAN	F(X)	F(Y)	MOMENT
15	-8.122E+04	-3.794E+03	1.762E+05
16	8.122E+04	6.707E+02	-1.762E+05
	---------	---------	---------
	-9.750E-10	-3.123E+03	1.965E-08

JOINT: 3

SPAN	F(X)	F(Y)	MOMENT
16	-8.122E+04	3.548E+02	1.923E+05
17	2.094E+05	1.786E+04	3.562E+04
25	-7.102E+03	4.128E+04	-2.291E+05
47	-7.802E+04	-1.157E+05	-5.408E+03
50	-4.302E+04	5.287E+04	6.662E+03
	---------	---------	---------
	-1.179E-09	-3.320E+03	3.308E-08

JOINT: 4

SPAN	F(X)	F(Y)	MOMENT
17	-2.094E+05	-1.665E+04	2.035E+06
18	2.113E+05	-1.381E+04	-1.967E+06
27	-1.973E+03	2.608E+04	-6.808E+04
	---------	---------	---------
	4.547E-12	-4.380E+03	9.677E-09

JOINT: 5

SPAN	F(X)	F(Y)	MOMENT
18	-2.113E+05	1.501E+04	2.374E+05
19	2.398E+05	6.078E+03	-3.361E+05
29	3.019E+03	2.535E+04	9.874E+04
49	-3.803E+04	-4.641E+04	-6.819E+03
52	6.505E+03	-7.799E+03	6.755E+03
	---------	---------	---------
	-1.010E-10	-7.769E+03	3.054E-09

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STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

JOINT: 6

AN	F(X)	F(Y)	MOMENT
9	-2.398E+05	-4.871E+03	9.930E+05
0	2.350E+05	-4.727E+03	-1.153E+06
1	4.852E+03	5.161E+03	1.595E+05
	---------	---------	---------
	2.401E-10	-4.437E+03	2.983E-09

JOINT: 7

AN	F(X)	F(Y)	MOMENT
0	-2.350E+05	5.933E+03	5.129E+05
1	1.926E+05	-6.350E+03	-7.663E+05
3	7.499E+03	1.807E+04	2.533E+05
1	6.589E+03	8.241E+03	-6.724E+03
4	2.833E+04	-3.453E+04	6.805E+03
	---------	---------	---------
	-9.095E-13	-8.643E+03	8.470E-09

JOINT: 8

AN	F(X)	F(Y)	MOMENT
1	-1.926E+05	8.763E+03	-1.047E+06
5	4.003E+03	2.135E+04	1.117E+05
5	1.568E+05	-6.811E+04	9.401E+05
3	3.033E+04	3.732E+04	-6.753E+03
5	1.394E+03	-3.254E+03	2.370E+03
	---------	---------	---------
	-7.066E-11	-3.926E+03	2.636E-09

JOINT: 9

IN	F(X)	F(Y)	MOMENT
	-1.249E+04	8.960E+03	1.015E+06
	-2.068E+03	-1.300E+05	-2.122E+05
	4.300E+03	1.043E+05	-1.213E+05
	1.026E+04	5.599E+03	-6.817E+05
	---------	---------	---------
	2.819E-11	-1.110E+04	7.567E-10

JOINT: 10

IN	F(X)	F(Y)	MOMENT
	1.249E+04	-7.571E+03	6.214E+05
	-1.783E+04	1.024E+04	-1.804E+05
	-1.762E+03	3.746E+04	-2.014E+05
	7.102E+03	-4.111E+04	-2.396E+05
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	6.548E-11	-9.770E+02	8.149E-09

JOINT: 11

SPAN	F(X)	F(Y)	MOMENT
10	1.783E+04	-9.399E+03	1.359E+06
11	-1.881E+04	-7.864E+03	-1.181E+06
26	-9.976E+02	2.553E+04	-1.151E+05
27	1.973E+03	-2.591E+04	-6.214E+04
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	9.243E-11	-1.764E+04	-2.925E-09

JOINT: 12

SPAN	F(X)	F(Y)	MOMENT
11	1.881E+04	8.706E+03	1.873E+05
12	-1.545E+04	3.398E+03	-2.475E+05
28	-3.417E+02	-1.194E+03	-4.031E+04
29	-3.019E+03	-2.518E+04	1.005E+05
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	9.516E-11	-1.427E+04	-2.103E-08

JOINT: 13

SPAN	F(X)	F(Y)	MOMENT
12	1.545E+04	-2.556E+03	6.047E+05
13	-1.061E+04	-4.940E+03	-7.671E+05
30	1.981E+01	-2.388E+03	1.674E+03
31	-4.852E+03	-4.989E+03	1.607E+05
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	7.458E-11	-1.487E+04	-5.035E-09

JOINT: 14

SPAN	F(X)	F(Y)	MOMENT
13	1.061E+04	5.782E+03	1.237E+05
14	-3.522E+03	-1.751E+03	-4.117E+05
32	4.069E+02	-6.968E+03	4.626E+04
33	-7.499E+03	-1.790E+04	2.417E+05
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	5.002E-11	-2.083E+04	-3.944E-09

JOINT: 15

SPAN	F(X)	F(Y)	MOMENT
14	3.522E+03	3.435E+03	-2.107E+05
34	4.808E+02	1.729E+04	5.817E+04
35	-4.003E+03	-2.118E+04	1.525E+05
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	3.047E-11	-4.600E+02	-5.966E-10

STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

JOINT: 16

AN	F(X)	F(Y)	MOMENT
1	-8.009E+04	1.947E+04	2.544E+05
2	2.068E+03	1.306E+05	-2.594E+05
7	7.802E+04	1.160E+05	4.967E+03
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	1.400E-08	2.661E+05	3.968E-09

JOINT: 17

AN	F(X)	F(Y)	MOMENT
1	8.009E+04	-1.851E+04	1.569E+06
2	-8.009E+04	-8.942E+03	-1.569E+06
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	-1.892E-10	-2.745E+04	2.747E-08

JOINT: 18

AN	F(X)	F(Y)	MOMENT
2	8.009E+04	9.968E+03	6.041E+05
3	-1.865E+05	1.468E+04	-4.051E+05
4	1.762E+03	-3.687E+04	-2.003E+05
8	6.666E+04	-9.882E+04	-5.377E+03
9	3.803E+04	4.675E+04	6.644E+03
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	-2.483E-10	-6.429E+04	1.548E-08

JOINT: 19

AN	F(X)	F(Y)	MOMENT
3	1.865E+05	-1.347E+04	2.094E+06
4	-1.875E+05	-1.489E+04	-1.982E+06
5	9.976E+02	-2.493E+04	-1.123E+05
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	-4.753E-10	-5.330E+04	4.002E-09

JOINT: 20

AN	F(X)	F(Y)	MOMENT
4	1.875E+05	1.610E+04	1.227E+05
5	-2.243E+05	9.125E+03	-8.507E+04
8	3.417E+02	1.789E+03	-3.760E+04
0	4.302E+04	-5.253E+04	-6.800E+03
[illegible]	-6.589E+03	-7.902E+03	6.767E+03
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	-1.431E-09	-3.342E+04	3.138E-10

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STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

JOINT: 21

SPAN	F(X)	F(Y)	MOMENT
5	2.243E+05	-7.919E+03	1.108E+06
6	-2.243E+05	-7.069E+03	-1.111E+06
30	-1.981E+01	2.983E+03	2.843E+03
	-4.895E-10	-1.200E+04	-8.640E-11

JOINT: 22

SPAN	F(X)	F(Y)	MOMENT
6	2.243E+05	8.275E+03	1.899E+05
7	-1.870E+05	2.619E+03	-2.365E+05
32	-4.069E+02	7.563E+03	4.650E+04
52	-6.505E+03	8.138E+03	-6.735E+03
53	-3.033E+04	-3.698E+04	6.787E+03
	-2.369E-09	-1.038E+04	-1.340E-08

JOINT: 23

SPAN	F(X)	F(Y)	MOMENT
7	1.870E+05	-1.412E+03	4.783E+05
8	-1.870E+05	-1.140E+04	-4.783E+05
	-6.985E-10	-1.281E+04	-1.164E-09

JOINT: 24

SPAN	F(X)	F(Y)	MOMENT
8	1.870E+05	1.260E+04	-9.617E+05
34	-4.808E+02	-1.669E+04	5.146E+04
40	-1.545E+05	-3.146E+04	9.147E+05
54	-2.833E+04	3.487E+04	-6.732E+03
55	-3.738E+03	-8.036E+03	2.179E+03
	-7.833E-10	-8.710E+03	-6.902E-09

JOINT: 25

SPAN	F(X)	F(Y)	MOMENT
36	-1.568E+05	6.934E+04	2.310E+05
37	1.511E+05	-7.432E+04	-2.292E+05
44	-5.967E-01	-2.345E+02	-1.257E+03
55	3.738E+03	8.270E+03	-2.116E+03
58	1.961E+03	-3.395E+03	1.600E+03
	-3.704E-10	-3.400E+02	-2.754E-09

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STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

JOINT: 26

AN	F(X)	F(Y)	MOMENT
7	-1.511E+05	7.548E+04	4.120E+05
3	1.493E+05	-7.717E+04	-4.183E+05
5	1.247E+02	-1.182E+03	7.772E+03
7	1.696E+03	2.685E+03	-1.421E+03
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	1.143E-10	-1.850E+02	-4.361E-10

JOINT: 27

AN	F(X)	F(Y)	MOMENT
3	-1.493E+05	7.833E+04	2.129E+05
9	1.473E+05	-7.738E+04	-2.644E+05
5	2.034E+03	-1.031E+03	5.147E+04
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	-1.883E-10	-8.000E+01	-3.463E-09

JOINT: 28

IN	F(X)	F(Y)	MOMENT
)	-1.473E+05	7.814E+04	5.318E+04
)	1.473E+05	4.379E+04	-5.318E+04
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	-2.823E-09	1.219E+05	-1.624E-08

JOINT: 29

IN	F(X)	F(Y)	MOMENT
)	1.545E+05	3.260E+04	1.155E+02
	-1.514E+05	-3.455E+04	-3.874E+02
	5.967E-01	6.209E+02	1.132E+03
	-1.394E+03	3.510E+03	-2.308E+03
	-1.696E+03	-2.517E+03	1.448E+03
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	4.094E-10	-3.400E+02	-1.224E-08

OINT: 30

N	F(X)	F(Y)	MOMENT
	1.514E+05	3.562E+04	4.631E+05
	-1.493E+05	-4.081E+04	-4.700E+05
	-1.247E+02	1.422E+03	8.545E+03
	-1.961E+03	3.582E+03	-1.591E+03
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	-2.499E-09	-1.850E+02	-9.923E-09

STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

JOINT: 31

SPAN	F(X)	F(Y)	MOMENT
42	1.493E+05	4.188E+04	2.325E+05
43	-1.473E+05	-4.308E+04	-2.864E+05
46	-2.034E+03	1.126E+03	5.390E+04
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	-3.938E-10	-8.000E+01	-1.390E-08

JOINT: 32

SPAN	F(X)	F(Y)	MOMENT
59	1.026E+04	4.673E+03	-3.802E+03
60	-1.026E+04	-4.673E+03	3.802E+03
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	4.093E-11	7.276E-12	1.200E-09

	FORE END FORCES				AFT END FORCES			
SPAN	JT.	AXIAL	SHEAR	MOMENT	JT.	AXIAL	SHEAR	MOMENT
1	16	-8.01E+04	1.95E+04	2.54E+05	17	8.01E+04	-1.85E+04	1.57E+06
2	17	-8.01E+04	-8.94E+03	-1.57E+06	18	8.01E+04	9.97E+03	6.04E+05
3	18	-1.87E+05	1.47E+04	-4.05E+05	19	1.87E+05	-1.35E+04	2.09E+06
4	19	-1.88E+05	-1.49E+04	-1.98E+06	20	1.88E+05	1.61E+04	1.23E+05
5	20	-2.24E+05	9.13E+03	-8.51E+04	21	2.24E+05	-7.92E+03	1.11E+06
6	21	-2.24E+05	-7.07E+03	-1.11E+06	22	2.24E+05	8.28E+03	1.90E+05
7	22	-1.87E+05	2.62E+03	-2.36E+05	23	1.87E+05	-1.41E+03	4.78E+05
8	23	-1.87E+05	-1.14E+04	-4.78E+05	24	1.87E+05	1.26E+04	-9.62E+05
9	9	-1.25E+04	8.96E+03	1.02E+06	10	1.25E+04	-7.57E+03	6.21E+05
10	10	-1.78E+04	1.02E+04	-1.80E+05	11	1.78E+04	-9.40E+03	1.36E+06
11	11	-1.88E+04	-7.86E+03	-1.18E+06	12	1.88E+04	8.71E+03	1.87E+05
12	12	-1.54E+04	3.40E+03	-2.47E+05	13	1.54E+04	-2.56E+03	6.05E+05
13	13	-1.06E+04	-4.94E+03	-7.67E+05	14	1.06E+04	5.78E+03	1.24E+05
14	14	-3.52E+03	-1.75E+03	-4.12E+05	15	3.52E+03	3.43E+03	-2.11E+05
15	1	8.12E+04	4.76E+03	2.34E+05	2	-8.12E+04	-3.79E+03	1.76E+05
16	2	8.12E+04	6.71E+02	-1.76E+05	3	-8.12E+04	3.55E+02	1.92E+05
17	3	2.09E+05	1.79E+04	3.56E+04	4	-2.09E+05	-1.67E+04	2.03E+06
18	4	2.11E+05	-1.38E+04	-1.97E+06	5	-2.11E+05	1.50E+04	2.37E+05
19	5	2.40E+05	6.08E+03	-3.36E+05	6	-2.40E+05	-4.87E+03	9.93E+05
20	6	2.35E+05	-4.73E+03	-1.15E+06	7	-2.35E+05	5.93E+03	5.13E+05
21	7	1.93E+05	-6.35E+03	-7.66E+05	8	-1.93E+05	8.76E+03	-1.05E+06
22	16	1.31E+05	-2.07E+03	-2.59E+05	9	-1.30E+05	2.07E+03	-2.12E+05
23	9	1.04E+05	-4.30E+03	-1.21E+05	1	-1.04E+05	4.30E+03	-1.63E+05
24	18	-3.69E+04	-1.76E+03	-2.00E+05	10	3.75E+04	1.76E+03	-2.01E+05
25	10	-4.11E+04	-7.10E+03	-2.40E+05	3	4.13E+04	7.10E+03	-2.29E+05
26	19	-2.49E+04	-9.98E+02	-1.12E+05	11	2.55E+04	9.98E+02	-1.15E+05
27	11	-2.59E+04	-1.97E+03	-6.21E+04	4	2.61E+04	1.97E+03	-6.81E+04
28	20	1.79E+03	-3.42E+02	-3.76E+04	12	-1.19E+03	3.42E+02	-4.03E+04
29	12	-2.52E+04	3.02E+03	1.01E+05	5	2.53E+04	-3.02E+03	9.87E+04
30	21	2.98E+03	1.98E+01	2.84E+03	13	-2.39E+03	-1.98E+01	1.67E+03
31	13	-4.99E+03	4.85E+03	1.61E+05	6	5.16E+03	-4.85E+03	1.60E+05
32	22	7.56E+03	4.07E+02	4.65E+04	14	-6.97E+03	-4.07E+02	4.63E+04

STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

	FORE END FORCES				AFT END FORCES			
AN JT.	AXIAL	SHEAR	MOMENT	JT.	AXIAL	SHEAR	MOMENT
3 14	-1.79E+04	7.50E+03	2.42E+05	7	1.81E+04	-7.50E+03	2.53E+05
4 24	-1.67E+04	4.81E+02	5.15E+04	15	1.73E+04	-4.81E+02	5.82E+04
5 15	-2.12E+04	4.00E+03	1.53E+05	8	2.14E+04	-4.00E+03	1.12E+05
6 8	1.71E+05	1.01E+04	9.40E+05	25	-1.71E+05	-9.00E+03	2.31E+05
7 25	1.68E+05	2.10E+03	-2.29E+05	26	-1.69E+05	-1.07E+03	4.12E+05
8 26	1.68E+05	-1.26E+03	-4.18E+05	27	-1.69E+05	2.30E+03	2.13E+05
9 27	1.66E+05	-2.45E+03	-2.64E+05	28	-1.67E+05	3.13E+03	5.32E+04
0 24	-1.57E+05	8.64E+03	9.15E+05	29	1.58E+05	-7.54E+03	1.16E+02
1 29	-1.55E+05	4.87E+03	-3.87E+02	30	1.55E+05	-3.83E+03	4.63E+05
2 30	-1.55E+05	-1.72E+03	-4.70E+05	31	1.55E+05	2.75E+03	2.33E+05
3 31	-1.53E+05	-4.53E+03	-2.86E+05	28	1.54E+05	5.21E+03	-5.32E+04
4 29	6.21E+02	-5.97E-01	1.13E+03	25	-2.34E+02	5.97E-01	-1.26E+03
5 30	1.42E+03	1.25E+02	8.54E+03	26	-1.18E+03	-1.25E+02	7.77E+03
6 31	1.13E+03	2.03E+03	5.39E+04	27	-1.03E+03	-2.03E+03	5.15E+04
7 16	1.40E+05	8.70E+01	4.97E+03	3	-1.40E+05	8.95E+01	-5.41E+03
8 1	-1.19E+05	8.74E+01	5.05E+03	18	1.19E+05	8.92E+01	-5.38E+03
9 18	6.03E+04	1.07E+02	6.64E+03	5	-6.00E+04	1.07E+02	-6.82E+03
0 3	-6.82E+04	1.07E+02	6.66E+03	20	6.79E+04	1.07E+02	-6.80E+03
. 20	-1.03E+04	1.07E+02	6.77E+03	7	1.06E+04	1.07E+02	-6.72E+03
2 5	1.02E+04	1.07E+02	6.75E+03	22	-1.04E+04	1.07E+02	-6.74E+03
3 22	-4.78E+04	1.07E+02	6.79E+03	8	4.81E+04	1.07E+02	-6.75E+03
4 7	4.47E+04	1.07E+02	6.80E+03	24	-4.49E+04	1.07E+02	-6.73E+03
5 24	-8.86E+03	4.90E+01	2.18E+03	25	9.08E+03	4.85E+01	-2.12E+03
6 8	3.54E+03	4.90E+01	2.37E+03	29	-3.78E+03	4.86E+01	-2.31E+03
7 29	-3.03E+03	4.60E+01	1.45E+03	26	3.18E+03	4.57E+01	-1.42E+03
8 25	3.92E+03	4.59E+01	1.60E+03	30	-4.08E+03	4.58E+01	-1.59E+03
9 32	1.13E+04	-4.09E+02	-3.80E+03	1	-1.11E+04	6.85E+02	-7.69E+04
0 32	-1.03E+04	-4.67E+03	3.80E+03	9	1.03E+04	5.60E+03	-6.82E+05

STRESS CALCULATIONS

AN	END	MZ/SM	MY/SM	P/A	SHEAR
	AFT	5.157E+03	.000E+00	2.262E+03	.000E+00
	FORE	-5.157E+03	.000E+00	2.262E+03	.000E+00
	AFT	6.886E+03	.000E+00	5.269E+03	.000E+00
	FORE	-6.516E+03	.000E+00	5.297E+03	.000E+00
	AFT	3.642E+03	.000E+00	6.336E+03	.000E+00
	FORE	-3.651E+03	.000E+00	6.336E+03	.000E+00
	AFT	1.573E+03	.000E+00	5.284E+03	.000E+00
	AFT	-3.162E+03	.000E+00	5.284E+03	.000E+00
	FORE	5.140E+03	.000E+00	5.058E+02	.000E+00
	AFT	6.880E+03	.000E+00	7.219E+02	.000E+00
	FORE	-5.982E+03	.000E+00	7.614E+02	.000E+00
	AFT	3.062E+03	.000E+00	6.254E+02	.000E+00
	FORE	-3.884E+03	.000E+00	4.297E+02	.000E+00
	FORE	-2.084E+03	.000E+00	1.426E+02	.000E+00
	FORE	7.705E+02	.000E+00	-2.294E+03	.000E+00
	AFT	6.321E+02	.000E+00	-2.294E+03	.000E+00
	AFT	6.690E+03	.000E+00	-5.914E+03	.000E+00
	FORE	-6.466E+03	.000E+00	-5.970E+03	.000E+00
	AFT	3.265E+03	.000E+00	-6.775E+03	.000E+00

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STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

STRESS CALCULATIONS

SPAN	END	MZ/SM	MY/SM	P/A	SHEAR
20	FORE	-3.789E+03	.000E+00	-6.638E+03	.000E+00
21	AFT	-3.443E+03	.000E+00	-5.440E+03	.000E+00
22	FORE	-1.178E+04	.000E+00	-1.421E+04	.000E+00
23	AFT	-7.379E+03	.000E+00	-1.133E+04	.000E+00
24	AFT	-9.145E+03	.000E+00	4.076E+03	.000E+00
25	FORE	-1.088E+04	.000E+00	4.473E+03	.000E+00
26	AFT	-5.226E+03	.000E+00	2.778E+03	.000E+00
27	AFT	-3.091E+03	.000E+00	2.838E+03	.000E+00
28	AFT	-1.830E+03	.000E+00	-1.300E+02	.000E+00
29	FORE	4.564E+03	.000E+00	2.740E+03	.000E+00
30	FORE	1.291E+02	.000E+00	-3.245E+02	.000E+00
31	FORE	7.295E+03	.000E+00	5.428E+02	.000E+00
32	FORE	2.111E+03	.000E+00	-8.229E+02	.000E+00
33	AFT	1.150E+04	.000E+00	1.966E+03	.000E+00
34	AFT	2.641E+03	.000E+00	1.881E+03	.000E+00
35	FORE	6.924E+03	.000E+00	2.305E+03	.000E+00
36	FORE	3.091E+03	.000E+00	-4.822E+03	.000E+00
37	AFT	1.354E+03	.000E+00	-4.772E+03	.000E+00
38	FORE	-1.375E+03	.000E+00	-4.748E+03	.000E+00
39	FORE	-8.693E+02	.000E+00	-4.699E+03	.000E+00
40	FORE	3.007E+03	.000E+00	4.447E+03	.000E+00
41	AFT	1.522E+03	.000E+00	4.393E+03	.000E+00
42	FORE	-1.545E+03	.000E+00	4.373E+03	.000E+00
43	FORE	-9.416E+02	.000E+00	4.333E+03	.000E+00
44	FORE	7.752E+01	.000E+00	-9.582E+01	.000E+00
45	FORE	5.853E+02	.000E+00	-2.195E+02	.000E+00
46	FORE	3.691E+03	.000E+00	-1.738E+02	.000E+00
47	AFT	-2.759E+04	.000E+00	-4.444E+04	.000E+00
48	AFT	-2.743E+04	.000E+00	3.796E+04	.000E+00
49	AFT	-3.479E+04	.000E+00	-1.911E+04	.000E+00
50	AFT	-3.469E+04	.000E+00	2.163E+04	.000E+00
51	FORE	3.452E+04	.000E+00	3.277E+03	.000E+00
52	FORE	3.446E+04	.000E+00	-3.234E+03	.000E+00
53	FORE	3.463E+04	.000E+00	1.523E+04	.000E+00
54	FORE	3.472E+04	.000E+00	-1.423E+04	.000E+00
55	FORE	1.112E+04	.000E+00	2.823E+03	.000E+00
56	FORE	1.209E+04	.000E+00	-1.127E+03	.000E+00
57	FORE	7.386E+03	.000E+00	9.665E+02	.000E+00
58	AFT	-8.117E+03	.000E+00	-1.301E+03	.000E+00
59	AFT	-3.204E+03	.000E+00	-1.514E+03	.000E+00
60	AFT	-3.452E+03	.000E+00	4.154E+02	.000E+00

STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

	STRAIN ENERGY		COMPONENTS			
AN	TOTAL	PER-CENT	BENDING	SHEAR	AXIAL	TORSION
1	7.44E+02	.5	3.26E+02	1.18E+02	3.00E+02	.00E+00
2	9.65E+02	.6	6.15E+02	3.12E+01	3.19E+02	.00E+00
3	3.15E+03	2.0	1.04E+03	8.12E+01	2.03E+03	.00E+00
4	2.96E+03	1.9	8.06E+02	9.84E+01	2.06E+03	.00E+00
5	3.23E+03	2.0	2.59E+02	2.98E+01	2.94E+03	.00E+00
6	3.25E+03	2.0	2.89E+02	2.42E+01	2.94E+03	.00E+00
7	2.13E+03	1.3	8.02E+01	1.71E+00	2.04E+03	.00E+00
8	2.23E+03	1.4	1.28E+02	5.90E+01	2.04E+03	.00E+00
9	4.43E+02	.3	3.65E+02	5.63E+01	2.16E+01	.00E+00
0	7.04E+02	.4	6.29E+02	4.80E+01	2.66E+01	.00E+00
1	5.55E+02	.3	4.91E+02	3.42E+01	2.96E+01	.00E+00
2	1.99E+02	.1	1.74E+02	4.44E+00	2.00E+01	.00E+00
3	2.34E+02	.1	2.10E+02	1.43E+01	9.44E+00	.00E+00
4	9.72E+01	.1	8.82E+01	6.93E+00	2.08E+00	.00E+00
5	3.21E+02	.2	6.58E+00	6.02E+00	3.08E+02	.00E+00
6	3.46E+02	.2	1.80E+01	3.92E-02	3.28E+02	.00E+00
7	3.47E+03	2.2	7.83E+02	1.22E+02	2.56E+03	.00E+00
8	3.54E+03	2.2	8.45E+02	8.51E+01	2.61E+03	.00E+00
9	3.65E+03	2.3	2.80E+02	1.23E+01	3.36E+03	.00E+00
0	3.66E+03	2.3	4.24E+02	1.17E+01	3.23E+03	.00E+00
1	4.70E+03	2.9	3.21E+02	4.72E+01	4.33E+03	.00E+00
2	8.12E+03	5.1	8.52E+02	1.03E+01	7.26E+03	.00E+00
3	1.45E+03	.9	9.22E+01	1.28E+01	1.35E+03	.00E+00
4	1.20E+03	.8	6.00E+02	7.44E+00	5.91E+02	.00E+00
5	4.82E+02	.3	2.37E+02	3.50E+01	2.10E+02	.00E+00
6	4.67E+02	.3	1.92E+02	2.39E+00	2.72E+02	.00E+00
7	1.05E+02	.1	1.84E+01	2.70E+00	8.37E+01	.00E+00
8	2.39E+01	.0	2.27E+01	2.80E-01	9.65E-01	.00E+00
9	1.28E+02	.1	4.28E+01	6.33E+00	7.90E+01	.00E+00
0	3.19E+00	.0	9.11E-02	9.41E-04	3.10E+00	.00E+00
1	1.30E+02	.1	1.10E+02	1.63E+01	3.19E+00	.00E+00
2	5.50E+01	.0	3.20E+01	3.97E-01	2.26E+01	.00E+00
3	3.43E+02	.2	2.64E+02	3.90E+01	4.00E+01	.00E+00
4	1.69E+02	.1	4.52E+01	5.54E-01	1.23E+02	.00E+00
5	1.48E+02	.1	8.05E+01	1.11E+01	5.60E+01	.00E+00
6	1.92E+03	1.2	1.34E+02	3.82E+01	1.75E+03	.00E+00
7	1.66E+03	1.0	6.11E+01	1.02E+00	1.60E+03	.00E+00
8	1.65E+03	1.0	5.97E+01	1.28E+00	1.59E+03	.00E+00
9	1.03E+03	.6	1.08E+01	2.02E+00	1.02E+03	.00E+00
0	1.54E+03	1.0	1.44E+02	2.53E+01	1.37E+03	.00E+00
.	1.30E+03	.8	3.81E+01	6.90E+00	1.25E+03	.00E+00
2	1.31E+03	.8	6.76E+01	1.84E+00	1.24E+03	.00E+00
3	8.14E+02	.5	7.96E+00	5.65E+00	8.00E+02	.00E+00
4	1.98E-01	.0	8.85E-02	9.76E-07	1.09E-01	.00E+00
5	1.48E+00	.0	8.63E-01	2.65E-02	5.92E-01	.00E+00
6	1.71E+01	.0	1.42E+01	2.80E+00	1.60E-01	.00E+00
7	3.81E+04	23.9	1.70E+02	1.36E-02	3.80E+04	.00E+00
8	2.79E+04	17.5	1.70E+02	1.36E-02	2.77E+04	.00E+00
9	7.84E+03	4.9	3.06E+02	2.13E-02	7.53E+03	.00E+00
0	9.95E+03	6.2	3.06E+02	2.13E-02	9.65E+03	.00E+00
	5.32E+02	.3	3.06E+02	2.13E-02	2.26E+02	.00E+00
2	5.26E+02	.3	3.06E+02	2.13E-02	2.21E+02	.00E+00

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STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

	STRAIN ENERGY		COMPONENTS			
SPAN	TOTAL	PER-CENT	BENDING	SHEAR	AXIAL	TORSION
53	5.10E+03	3.2	3.06E+02	2.13E-02	4.79E+03	.00E+00
54	4.49E+03	2.8	3.06E+02	2.13E-02	4.18E+03	.00E+00
55	1.37E+02	.1	2.10E+01	3.07E-03	1.16E+02	.00E+00
56	4.86E+01	.0	2.75E+01	3.35E-03	2.11E+01	.00E+00
57	1.69E+01	.0	6.88E+00	1.95E-03	9.98E+00	.00E+00
58	2.80E+01	.0	9.53E+00	2.17E-03	1.85E+01	.00E+00
59	7.29E+01	.0	2.91E+01	4.39E-01	4.34E+01	.00E+00
60	1.67E+02	.1	1.43E+02	1.45E+01	9.70E+00	.00E+00

TOTAL STRAIN ENERGY = 1.596E+05

9 2 1 2 5 0 1 0 3 7 2

STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

* LOADING NO. 2: WIND AND DEAD LOADING

JOINT DISPLACEMENTS

INT	X	Y	ROTATION
1	7.995E-02	-1.433E-01	-2.979E-03
2	7.197E-02	-4.363E-01	-3.006E-03
3	6.349E-02	-7.343E-01	-2.832E-03
4	3.752E-02	-1.043E+00	-1.658E-03
5	1.127E-02	-1.132E+00	-3.541E-04
6	-1.892E-02	-1.137E+00	5.036E-04
7	-4.854E-02	-9.981E-01	1.599E-03
8	-9.725E-02	-5.344E-01	1.385E-03
9	-5.083E-02	-1.162E-01	-2.428E-03
0	-4.727E-02	-7.446E-01	-2.971E-03
1	-4.417E-02	-1.050E+00	-1.580E-03
2	-4.086E-02	-1.138E+00	-3.293E-04
3	-3.808E-02	-1.139E+00	5.170E-04
4	-3.613E-02	-1.004E+00	1.433E-03
5	-3.481E-02	-5.400E-01	1.970E-03
6	.000E+00	.000E+00	-4.591E-03
7	7.900E-03	-4.379E-01	-3.992E-03
8	1.629E-02	-7.765E-01	-2.924E-03
9	3.954E-02	-1.071E+00	-1.451E-03
0	6.291E-02	-1.136E+00	-2.068E-04
1	9.120E-02	-1.135E+00	5.783E-04
2	1.195E-01	-9.941E-01	1.459E-03
3	1.432E-01	-7.947E-01	1.917E-03
4	1.668E-01	-5.553E-01	1.615E-03
5	-6.322E-02	-4.185E-01	9.408E-04
6	-2.387E-02	-2.958E-01	1.324E-03
7	3.874E-02	-1.274E-01	1.703E-03
8	8.847E-02	.000E+00	1.827E-03
9	1.503E-01	-4.181E-01	1.100E-03
0	1.360E-01	-2.948E-01	1.357E-03
1	1.100E-01	-1.270E-01	1.743E-03
2	-5.278E-02	1.401E-01	-1.768E-03

JOINT REACTIONS

INT	F(X)	F(Y)	MOMENT
6	1.496E-08	2.782E+05	.000E+00
8	.000E+00	1.311E+05	.000E+00

STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

SUMMATION OF FORCES AT JOINTS

JOINT: 1

SPAN	F(X)	F(Y)	MOMENT
15	8.532E+04	4.723E+03	2.412E+05
23	-4.427E+03	-1.093E+05	-1.674E+05
48	-7.026E+04	1.045E+05	5.041E+03
59	-1.063E+04	-4.535E+03	-7.887E+04
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	-6.294E-10	-4.630E+03	6.519E-09

JOINT: 2

SPAN	F(X)	F(Y)	MOMENT
15	-8.532E+04	-3.758E+03	1.658E+05
16	8.532E+04	6.345E+02	-1.658E+05
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	-3.638E-10	-3.123E+03	1.476E-08

JOINT: 3

SPAN	F(X)	F(Y)	MOMENT
16	-8.532E+04	3.909E+02	1.782E+05
17	2.222E+05	1.870E+04	6.265E+04
25	-7.499E+03	4.176E+04	-2.421E+05
47	-8.231E+04	-1.221E+05	-5.419E+03
50	-4.711E+04	5.788E+04	6.653E+03
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	-1.291E-09	-3.320E+03	2.559E-08

JOINT: 4

SPAN	F(X)	F(Y)	MOMENT
17	-2.222E+05	-1.750E+04	2.110E+06
18	2.246E+05	-1.425E+04	-2.029E+06
27	-2.338E+03	2.737E+04	-8.020E+04
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	3.092E-11	-4.380E+03	1.959E-08

JOINT: 5

SPAN	F(X)	F(Y)	MOMENT
18	-2.246E+05	1.545E+04	2.473E+05
19	2.583E+05	7.396E+03	-3.369E+05
29	2.747E+03	2.782E+04	8.970E+04
49	-4.221E+04	-5.154E+04	-6.825E+03
52	5.769E+03	-6.898E+03	6.751E+03
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	-1.673E-10	-7.769E+03	1.737E-08

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STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

JOINT: 6

AN	F(X)	F(Y)	MOMENT
9	-2.583E+05	-6.190E+03	1.152E+06
0	2.534E+05	-5.389E+03	-1.314E+06
1	4.908E+03	7.142E+03	1.615E+05
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	2.610E-10	-4.437E+03	7.174E-09

JOINT: 7

AN	F(X)	F(Y)	MOMENT
0	-2.534E+05	6.596E+03	5.945E+05
1	2.084E+05	-7.227E+03	-8.696E+05
3	8.140E+03	2.341E+04	2.751E+05
1	5.458E+03	6.855E+03	-6.720E+03
4	3.138E+04	-3.827E+04	6.807E+03
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	1.455E-11	-8.643E+03	1.182E-08

JOINT: 8

AN	F(X)	F(Y)	MOMENT
1	-2.084E+05	9.640E+03	-1.154E+06
5	4.486E+03	2.264E+04	1.254E+05
6	1.691E+05	-7.333E+04	1.033E+06
3	3.323E+04	4.088E+04	-6.751E+03
6	1.601E+03	-3.756E+03	2.374E+03
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	-4.150E-12	-3.926E+03	2.664E-09

JOINT: 9

AN	F(X)	F(Y)	MOMENT
9	-1.288E+04	9.189E+03	1.052E+06
2	-2.174E+03	-1.355E+05	-2.236E+05
3	4.427E+03	1.095E+05	-1.248E+05
0	1.063E+04	5.769E+03	-7.039E+05
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	4.184E-11	-1.110E+04	6.257E-10

JOINT: 10

AN	F(X)	F(Y)	MOMENT
9	1.288E+04	-7.800E+03	6.296E+05
0	-1.850E+04	1.086E+04	-1.620E+05
4	-1.880E+03	3.756E+04	-2.148E+05
5	7.499E+03	-4.159E+04	-2.529E+05
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	4.366E-11	-9.770E+02	5.821E-10

STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

JOINT: 11

SPAN	F(X)	F(Y)	MOMENT
10	1.850E+04	-1.002E+04	1.415E+06
11	-1.974E+04	-8.014E+03	-1.214E+06
26	-1.097E+03	2.464E+04	-1.265E+05
27	2.338E+03	-2.719E+04	-7.413E+04
	9.197E-11	-2.058E+04	-5.108E-09

JOINT: 12

SPAN	F(X)	F(Y)	MOMENT
11	1.974E+04	8.856E+03	2.017E+05
12	-1.657E+04	4.294E+03	-2.440E+05
28	-4.213E+02	-3.018E+03	-4.940E+04
29	-2.747E+03	-2.765E+04	9.161E+04
	1.075E-10	-1.752E+04	-2.648E-08

JOINT: 13

SPAN	F(X)	F(Y)	MOMENT
12	1.657E+04	-3.452E+03	7.087E+05
13	-1.165E+04	-5.465E+03	-8.692E+05
30	-1.126E+01	-4.623E+03	-1.971E+03
31	-4.908E+03	-6.970E+03	1.625E+05
	7.458E-11	-2.051E+04	-8.527E-09

JOINT: 14

SPAN	F(X)	F(Y)	MOMENT
13	1.165E+04	6.307E+03	1.629E+05
14	-3.957E+03	-2.119E+03	-4.756E+05
32	4.448E+02	-1.118E+04	5.041E+04
33	-8.140E+03	-2.323E+04	2.622E+05
	5.548E-11	-3.023E+04	-8.731E-11

JOINT: 15

SPAN	F(X)	F(Y)	MOMENT
14	3.957E+03	3.802E+03	-2.350E+05
34	5.291E+02	1.821E+04	6.430E+04
35	-4.486E+03	-2.247E+04	1.707E+05
	3.001E-11	-4.600E+02	-8.731E-11

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STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

JOINT: 16

AN	F(X)	F(Y)	MOMENT
1	-8.448E+04	1.965E+04	2.672E+05
2	2.174E+03	1.361E+05	-2.721E+05
7	8.231E+04	1.224E+05	4.956E+03
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	1.496E-08	2.782E+05	3.220E-09

JOINT: 17

AN	F(X)	F(Y)	MOMENT
1	8.448E+04	-1.868E+04	1.573E+06
2	-8.448E+04	-8.766E+03	-1.573E+06
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	-2.037E-10	-2.745E+04	3.166E-08

JOINT: 18

AN	F(X)	F(Y)	MOMENT
2	8.448E+04	9.792E+03	6.263E+05
3	-1.988E+05	1.517E+04	-4.138E+05
4	1.880E+03	-3.696E+04	-2.137E+05
8	7.026E+04	-1.042E+05	-5.388E+03
9	4.221E+04	5.188E+04	6.635E+03
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	-2.265E-10	-6.429E+04	2.305E-08

JOINT: 19

AN	F(X)	F(Y)	MOMENT
3	1.988E+05	-1.397E+04	2.162E+06
4	-1.999E+05	-1.529E+04	-2.038E+06
6	1.097E+03	-2.405E+04	-1.236E+05
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	-7.486E-10	-5.330E+04	4.671E-09

JOINT: 20

AN	F(X)	F(Y)	MOMENT
4	1.999E+05	1.649E+04	1.318E+05
5	-2.420E+05	1.053E+04	-8.511E+04
8	4.213E+02	3.613E+03	-4.665E+04
0	4.711E+04	-5.754E+04	-6.806E+03
1	-5.458E+03	-6.516E+03	6.763E+03
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	-1.270E-09	-3.342E+04	8.262E-09

STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

JOINT: 21

SPAN	F(X)	F(Y)	MOMENT
5	2.420E+05	-9.320E+03	1.276E+06
6	-2.420E+05	-7.903E+03	-1.275E+06
30	1.126E+01	5.218E+03	-5.970E+02
	-6.841E-10	-1.200E+04	1.470E-08

JOINT: 22

SPAN	F(X)	F(Y)	MOMENT
6	2.420E+05	9.110E+03	2.545E+05
7	-2.026E+05	2.033E+03	-3.056E+05
32	-4.448E+02	1.178E+04	5.100E+04
52	-5.769E+03	7.236E+03	-6.732E+03
53	-3.323E+04	-4.054E+04	6.789E+03
	-2.409E-09	-1.038E+04	1.076E-08

JOINT: 23

SPAN	F(X)	F(Y)	MOMENT
7	2.026E+05	-8.263E+02	4.771E+05
8	-2.026E+05	-1.198E+04	-4.771E+05
	-6.985E-10	-1.281E+04	1.863E-09

JOINT: 24

SPAN	F(X)	F(Y)	MOMENT
8	2.026E+05	1.319E+04	-1.033E+06
34	-5.291E+02	-1.761E+04	5.634E+04
40	-1.665E+05	-3.403E+04	9.814E+05
54	-3.138E+04	3.861E+04	-6.730E+03
55	-4.121E+03	-8.870E+03	2.183E+03
	-1.062E-09	-8.710E+03	9.207E-10

JOINT: 25

SPAN	F(X)	F(Y)	MOMENT
36	-1.691E+05	7.456E+04	2.433E+05
37	1.628E+05	-8.004E+04	-2.417E+05
44	1.731E+00	-1.968E+02	-1.104E+03
55	4.121E+03	9.104E+03	-2.114E+03
58	2.169E+03	-3.766E+03	1.600E+03
	-3.343E-10	-3.400E+02	-2.620E-09

STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

JOINT: 26

AN	F(X)	F(Y)	MOMENT
7	-1.628E+05	8.120E+04	4.423E+05
3	1.607E+05	-8.313E+04	-4.494E+05
5	1.375E+02	-1.287E+03	8.574E+03
7	1.919E+03	3.027E+03	-1.419E+03
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	-2.140E-10	-1.850E+02	-1.292E-09

JOINT: 27

AN	F(X)	F(Y)	MOMENT
3	-1.607E+05	8.429E+04	2.253E+05
9	1.585E+05	-8.325E+04	-2.809E+05
5	2.197E+03	-1.119E+03	5.560E+04
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	7.276E-12	-8.000E+01	-3.856E-09

JOINT: 28

AN	F(X)	F(Y)	MOMENT
9	-1.585E+05	8.401E+04	5.730E+04
3	1.585E+05	4.704E+04	-5.730E+04
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	-3.274E-09	1.311E+05	-1.763E-08

JOINT: 29

AN	F(X)	F(Y)	MOMENT
0	1.665E+05	3.517E+04	-3.198E+03
1	-1.630E+05	-3.724E+04	2.587E+03
4	-1.731E+00	5.832E+02	1.467E+03
5	-1.601E+03	4.012E+03	-2.305E+03
7	-1.919E+03	-2.859E+03	1.449E+03
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	6.137E-10	-3.400E+02	-1.372E-08

JOINT: 30

AN	F(X)	F(Y)	MOMENT
1	1.630E+05	3.831E+04	4.955E+05
2	-1.607E+05	-4.398E+04	-5.033E+05
5	-1.375E+02	1.528E+03	9.419E+03
3	-2.169E+03	3.953E+03	-1.589E+03
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	-2.472E-09	-1.850E+02	-1.063E-08

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STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

JOINT: 31

SPAN	F(X)	F(Y)	MOMENT
42	1.607E+05	4.505E+04	2.463E+05
43	-1.585E+05	-4.634E+04	-3.045E+05
46	-2.197E+03	1.215E+03	5.821E+04
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	-3.856E-10	-8.000E+01	-1.390E-08

JOINT: 32

SPAN	F(X)	F(Y)	MOMENT
59	1.063E+04	4.843E+03	-3.564E+03
60	-1.063E+04	-4.843E+03	3.564E+03
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	3.274E-11	-1.546E-11	1.054E-09

	FORE END FORCES				AFT END FORCES			
SPAN	JT.	AXIAL	SHEAR	MOMENT	JT.	AXIAL	SHEAR	MOMENT
1	16	-8.45E+04	1.96E+04	2.67E+05	17	8.45E+04	-1.87E+04	1.57E+06
2	17	-8.45E+04	-8.77E+03	-1.57E+06	18	8.45E+04	9.79E+03	6.26E+05
3	18	-1.99E+05	1.52E+04	-4.14E+05	19	1.99E+05	-1.40E+04	2.16E+06
4	19	-2.00E+05	-1.53E+04	-2.04E+06	20	2.00E+05	1.65E+04	1.32E+05
5	20	-2.42E+05	1.05E+04	-8.51E+04	21	2.42E+05	-9.32E+03	1.28E+06
6	21	-2.42E+05	-7.90E+03	-1.28E+06	22	2.42E+05	9.11E+03	2.55E+05
7	22	-2.03E+05	2.03E+03	-3.06E+05	23	2.03E+05	-8.26E+02	4.77E+05
8	23	-2.03E+05	-1.20E+04	-4.77E+05	24	2.03E+05	1.32E+04	-1.03E+06
9	9	-1.29E+04	9.19E+03	1.05E+06	10	1.29E+04	-7.80E+03	6.30E+05
10	10	-1.85E+04	1.09E+04	-1.62E+05	11	1.85E+04	-1.00E+04	1.41E+06
11	11	-1.97E+04	-8.01E+03	-1.21E+06	12	1.97E+04	8.86E+03	2.02E+05
12	12	-1.66E+04	4.29E+03	-2.44E+05	13	1.66E+04	-3.45E+03	7.09E+05
13	13	-1.17E+04	-5.46E+03	-8.69E+05	14	1.17E+04	6.31E+03	1.63E+05
14	14	-3.96E+03	-2.12E+03	-4.76E+05	15	3.96E+03	3.80E+03	-2.35E+05
15	1	8.53E+04	4.72E+03	2.41E+05	2	-8.53E+04	-3.76E+03	1.66E+05
16	2	8.53E+04	6.35E+02	-1.66E+05	3	-8.53E+04	3.91E+02	1.78E+05
17	3	2.22E+05	1.87E+04	6.27E+04	4	-2.22E+05	-1.75E+04	2.11E+06
18	4	2.25E+05	-1.42E+04	-2.03E+06	5	-2.25E+05	1.55E+04	2.47E+05
19	5	2.58E+05	7.40E+03	-3.37E+05	6	-2.58E+05	-6.19E+03	1.15E+06
20	6	2.53E+05	-5.39E+03	-1.31E+06	7	-2.53E+05	6.60E+03	5.94E+05
21	7	2.08E+05	-7.23E+03	-8.70E+05	8	-2.08E+05	9.64E+03	-1.15E+06
22	16	1.36E+05	-2.17E+03	-2.72E+05	9	-1.36E+05	2.17E+03	-2.24E+05
23	9	1.09E+05	-4.43E+03	-1.25E+05	1	-1.09E+05	4.43E+03	-1.67E+05
24	18	-3.70E+04	-1.88E+03	-2.14E+05	10	3.76E+04	1.88E+03	-2.15E+05
25	10	-4.16E+04	-7.50E+03	-2.53E+05	3	4.18E+04	7.50E+03	-2.42E+05
26	19	-2.40E+04	-1.10E+03	-1.24E+05	11	2.46E+04	1.10E+03	-1.26E+05
27	11	-2.72E+04	-2.34E+03	-7.41E+04	4	2.74E+04	2.34E+03	-8.02E+04
28	20	3.61E+03	-4.21E+02	-4.67E+04	12	-3.02E+03	4.21E+02	-4.94E+04
29	12	-2.76E+04	2.75E+03	9.16E+04	5	2.78E+04	-2.75E+03	8.97E+04
30	21	5.22E+03	-1.13E+01	-5.97E+02	13	-4.62E+03	1.13E+01	-1.97E+03
31	13	-6.97E+03	4.91E+03	1.62E+05	6	7.14E+03	-4.91E+03	1.61E+05
32	22	1.18E+04	4.45E+02	5.10E+04	14	-1.12E+04	-4.45E+02	5.04E+04

STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

AN	FORE END FORCES JT.	AXIAL	SHEAR	MOMENT	AFT END FORCES JT.	AXIAL	SHEAR	MOMENT
	14	-2.32E+04	8.14E+03	2.62E+05	7	2.34E+04	-8.14E+03	2.75E+05
	24	-1.76E+04	5.29E+02	5.63E+04	15	1.82E+04	-5.29E+02	6.43E+04
	15	-2.25E+04	4.49E+03	1.71E+05	8	2.26E+04	-4.49E+03	1.25E+05
	8	1.84E+05	1.10E+04	1.03E+06	25	-1.85E+05	-9.86E+03	2.43E+05
	25	1.81E+05	2.26E+03	-2.42E+05	26	-1.82E+05	-1.22E+03	4.42E+05
	26	1.81E+05	-1.43E+03	-4.49E+05	27	-1.81E+05	2.46E+03	2.25E+05
	27	1.79E+05	-2.62E+03	-2.81E+05	28	-1.79E+05	3.29E+03	5.73E+04
	24	-1.70E+05	9.20E+03	9.81E+05	29	1.70E+05	-8.10E+03	-3.20E+03
	29	-1.67E+05	5.20E+03	2.59E+03	30	1.67E+05	-4.17E+03	4.95E+05
	30	-1.67E+05	-1.90E+03	-5.03E+05	31	1.67E+05	2.93E+03	2.46E+05
	31	-1.65E+05	-4.85E+03	-3.04E+05	28	1.65E+05	5.53E+03	-5.73E+04
	29	5.83E+02	1.73E+00	1.47E+03	25	-1.97E+02	-1.73E+00	-1.10E+03
	30	1.53E+03	1.37E+02	9.42E+03	26	-1.29E+03	-1.37E+02	8.57E+03
	31	1.21E+03	2.20E+03	5.82E+04	27	-1.12E+03	-2.20E+03	5.56E+04
	16	1.47E+05	8.70E+01	4.96E+03	3	-1.47E+05	8.96E+01	-5.42E+03
	1	-1.26E+05	8.73E+01	5.04E+03	18	1.26E+05	8.93E+01	-5.39E+03
	18	6.69E+04	1.07E+02	6.64E+03	5	-6.66E+04	1.08E+02	-6.83E+03
	3	-7.46E+04	1.07E+02	6.65E+03	20	7.44E+04	1.07E+02	-6.81E+03
	20	-8.50E+03	1.07E+02	6.76E+03	7	8.76E+03	1.07E+02	-6.72E+03
	5	8.99E+03	1.07E+02	6.75E+03	22	-9.25E+03	1.07E+02	-6.73E+03
	22	-5.24E+04	1.07E+02	6.79E+03	8	5.27E+04	1.07E+02	-6.75E+03
	7	4.95E+04	1.07E+02	6.81E+03	24	-4.98E+04	1.07E+02	-6.73E+03
	24	-9.78E+03	4.90E+01	2.18E+03	25	9.99E+03	4.85E+01	-2.11E+03
	8	4.08E+03	4.90E+01	2.37E+03	29	-4.32E+03	4.85E+01	-2.30E+03
	29	-3.44E+03	4.60E+01	1.45E+03	26	3.58E+03	4.57E+01	-1.42E+03
	25	4.35E+03	4.59E+01	1.60E+03	30	-4.51E+03	4.58E+01	-1.59E+03
	32	1.17E+04	-4.21E+02	-3.56E+03	1	-1.15E+04	6.96E+02	-7.89E+04
	32	-1.06E+04	-4.84E+03	3.56E+03	9	1.06E+04	5.77E+03	-7.04E+05

STRESS CALCULATIONS

IN	END	MZ/SM	MY/SM	P/A	SHEAR
	AFT	5.171E+03	.000E+00	2.387E+03	.000E+00
	FORE	-5.171E+03	.000E+00	2.387E+03	.000E+00
	AFT	7.108E+03	.000E+00	5.617E+03	.000E+00
	FORE	-6.702E+03	.000E+00	5.648E+03	.000E+00
	AFT	4.195E+03	.000E+00	6.836E+03	.000E+00
	FORE	-4.193E+03	.000E+00	6.837E+03	.000E+00
	AFT	1.569E+03	.000E+00	5.722E+03	.000E+00
	AFT	-3.397E+03	.000E+00	5.722E+03	.000E+00
	FORE	5.328E+03	.000E+00	5.214E+02	.000E+00
	AFT	7.162E+03	.000E+00	7.489E+02	.000E+00
	FORE	-6.147E+03	.000E+00	7.992E+02	.000E+00
	AFT	3.588E+03	.000E+00	6.709E+02	.000E+00
	FORE	-4.401E+03	.000E+00	4.718E+02	.000E+00
	FORE	-2.408E+03	.000E+00	1.602E+02	.000E+00
	FORE	7.931E+02	.000E+00	-2.410E+03	.000E+00
	AFT	5.860E+02	.000E+00	-2.410E+03	.000E+00
	AFT	6.935E+03	.000E+00	-6.278E+03	.000E+00
	FORE	-6.672E+03	.000E+00	-6.344E+03	.000E+00
	AFT	3.788E+03	.000E+00	-7.296E+03	.000E+00

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STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

STRESS CALCULATIONS

SPAN	END	MZ/SM	MY/SM	P/A	SHEAR
20	FORE	-4.318E+03	.000E+00	-7.157E+03	.000E+00
21	AFT	-3.795E+03	.000E+00	-5.887E+03	.000E+00
22	FORE	-1.236E+04	.000E+00	-1.481E+04	.000E+00
23	AFT	-7.601E+03	.000E+00	-1.189E+04	.000E+00
24	AFT	-9.752E+03	.000E+00	4.087E+03	.000E+00
25	FORE	-1.148E+04	.000E+00	4.526E+03	.000E+00
26	AFT	-5.742E+03	.000E+00	2.681E+03	.000E+00
27	AFT	-3.641E+03	.000E+00	2.978E+03	.000E+00
28	AFT	-2.243E+03	.000E+00	-3.284E+02	.000E+00
29	FORE	4.159E+03	.000E+00	3.009E+03	.000E+00
30	FORE	-2.711E+01	.000E+00	-5.678E+02	.000E+00
31	FORE	7.378E+03	.000E+00	7.584E+02	.000E+00
32	FORE	2.315E+03	.000E+00	-1.281E+03	.000E+00
33	AFT	1.249E+04	.000E+00	2.547E+03	.000E+00
34	AFT	2.920E+03	.000E+00	1.981E+03	.000E+00
35	FORE	7.749E+03	.000E+00	2.445E+03	.000E+00
36	FORE	3.397E+03	.000E+00	-5.196E+03	.000E+00
37	AFT	1.454E+03	.000E+00	-5.138E+03	.000E+00
38	FORE	-1.478E+03	.000E+00	-5.111E+03	.000E+00
39	FORE	-9.235E+02	.000E+00	-5.057E+03	.000E+00
40	FORE	3.226E+03	.000E+00	4.795E+03	.000E+00
41	AFT	1.629E+03	.000E+00	4.729E+03	.000E+00
42	FORE	-1.655E+03	.000E+00	4.707E+03	.000E+00
43	FORE	-1.001E+03	.000E+00	4.663E+03	.000E+00
44	FORE	1.005E+02	.000E+00	-9.001E+01	.000E+00
45	FORE	6.451E+02	.000E+00	-2.359E+02	.000E+00
46	FORE	3.987E+03	.000E+00	-1.874E+02	.000E+00
47	AFT	-2.765E+04	.000E+00	-4.688E+04	.000E+00
48	AFT	-2.749E+04	.000E+00	4.002E+04	.000E+00
49	AFT	-3.482E+04	.000E+00	-2.122E+04	.000E+00
50	AFT	-3.472E+04	.000E+00	2.368E+04	.000E+00
51	FORE	3.451E+04	.000E+00	2.707E+03	.000E+00
52	FORE	3.444E+04	.000E+00	-2.864E+03	.000E+00
53	FORE	3.464E+04	.000E+00	1.669E+04	.000E+00
54	FORE	3.473E+04	.000E+00	-1.576E+04	.000E+00
55	FORE	1.114E+04	.000E+00	3.115E+03	.000E+00
56	FORE	1.211E+04	.000E+00	-1.300E+03	.000E+00
57	FORE	7.392E+03	.000E+00	1.097E+03	.000E+00
58	FORE	8.165E+03	.000E+00	-1.384E+03	.000E+00
59	AFT	-3.286E+03	.000E+00	-1.569E+03	.000E+00
60	AFT	-3.564E+03	.000E+00	4.302E+02	.000E+00

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STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

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	STRAIN ENERGY		COMPONENTS			
PAN	TOTAL	PER-CENT	BENDING	SHEAR	AXIAL	TORSION
1	7.80E+02	.4	3.26E+02	1.20E+02	3.34E+02	.00E+00
2	1.01E+03	.6	6.28E+02	3.00E+01	3.55E+02	.00E+00
3	3.50E+03	1.9	1.10E+03	8.70E+01	2.31E+03	.00E+00
4	3.29E+03	1.8	8.54E+02	1.03E+02	2.34E+03	.00E+00
5	3.80E+03	2.1	3.39E+02	4.04E+01	3.42E+03	.00E+00
6	3.84E+03	2.1	3.91E+02	2.97E+01	3.42E+03	.00E+00
7	2.49E+03	1.4	9.37E+01	8.87E-01	2.40E+03	.00E+00
8	2.61E+03	1.4	1.48E+02	6.49E+01	2.40E+03	.00E+00
9	4.73E+02	.3	3.91E+02	5.94E+01	2.29E+01	.00E+00
10	7.51E+02	.4	6.68E+02	5.43E+01	2.87E+01	.00E+00
11	5.91E+02	.3	5.22E+02	3.55E+01	3.26E+01	.00E+00
12	2.51E+02	.1	2.21E+02	7.50E+00	2.30E+01	.00E+00
13	3.05E+02	.2	2.76E+02	1.73E+01	1.14E+01	.00E+00
14	1.27E+02	.1	1.15E+02	8.96E+00	2.62E+00	.00E+00
15	3.53E+02	.2	6.67E+00	5.92E+00	3.40E+02	.00E+00
16	3.77E+02	.2	1.58E+01	3.57E-02	3.62E+02	.00E+00
17	3.85E+03	2.1	8.31E+02	1.34E+02	2.89E+03	.00E+00
18	3.94E+03	2.2	9.00E+02	9.04E+01	2.95E+03	.00E+00
19	4.27E+03	2.4	3.56E+02	1.90E+01	3.90E+03	.00E+00
20	4.32E+03	2.4	5.53E+02	1.48E+01	3.75E+03	.00E+00
21	5.53E+03	3.0	3.98E+02	5.87E+01	5.08E+03	.00E+00
22	8.84E+03	4.9	9.40E+02	1.13E+01	7.89E+03	.00E+00
23	1.59E+03	.9	9.78E+01	1.36E+01	1.48E+03	.00E+00
24	1.29E+03	.7	6.83E+02	8.47E+00	5.94E+02	.00E+00
25	5.18E+02	.3	2.64E+02	3.90E+01	2.15E+02	.00E+00
26	4.89E+02	.3	2.33E+02	2.88E+00	2.53E+02	.00E+00
27	1.22E+02	.1	2.58E+01	3.80E+00	9.21E+01	.00E+00
28	3.95E+01	.0	3.44E+01	4.26E-01	4.71E+00	.00E+00
29	1.36E+02	.1	3.54E+01	5.24E+00	9.52E+01	.00E+00
30	1.04E+01	.0	4.56E-02	3.04E-04	1.04E+01	.00E+00
31	1.36E+02	.1	1.13E+02	1.67E+01	6.17E+00	.00E+00
32	9.51E+01	.1	3.82E+01	4.74E-01	5.64E+01	.00E+00
33	4.25E+02	.2	3.11E+02	4.60E+01	6.73E+01	.00E+00
34	1.93E+02	.1	5.48E+01	6.71E-01	1.37E+02	.00E+00
35	1.78E+02	.1	1.01E+02	1.40E+01	6.30E+01	.00E+00
36	2.24E+03	1.2	1.64E+02	4.54E+01	2.03E+03	.00E+00
37	1.92E+03	1.1	6.93E+01	1.23E+00	1.85E+03	.00E+00
38	1.91E+03	1.1	6.80E+01	1.52E+00	1.85E+03	.00E+00
39	1.20E+03	.7	1.22E+01	2.26E+00	1.18E+03	.00E+00
40	1.78E+03	1.0	1.67E+02	2.89E+01	1.59E+03	.00E+00
1	1.50E+03	.8	4.32E+01	7.99E+00	1.45E+03	.00E+00
2	1.52E+03	.8	7.68E+01	2.15E+00	1.44E+03	.00E+00
3	9.42E+02	.5	8.95E+00	6.41E+00	9.27E+02	.00E+00
4	1.95E-01	.0	1.03E-01	8.21E-06	9.19E-02	.00E+00
5	1.77E+00	.0	1.05E+00	3.23E-02	6.92E-01	.00E+00
6	2.00E+01	.0	1.65E+01	3.26E+00	1.88E-01	.00E+00
7	4.24E+04	23.4	1.70E+02	1.36E-02	4.23E+04	.00E+00
8	3.10E+04	17.1	1.70E+02	1.36E-02	3.08E+04	.00E+00
9	9.59E+03	5.3	3.06E+02	2.13E-02	9.29E+03	.00E+00
0	1.19E+04	6.5	3.06E+02	2.13E-02	1.16E+04	.00E+00
1	4.61E+02	.3	3.06E+02	2.13E-02	1.55E+02	.00E+00
2	4.79E+02	.3	3.06E+02	2.13E-02	1.73E+02	.00E+00

STATIC ANALYSIS OF GENERAL STRUCTURES
WASTE RETRIEVAL SYSTEM

	STRAIN ENERGY		COMPONENTS			
SPAN	TOTAL	PER-CENT	BENDING	SHEAR	AXIAL	TORSION
53	6.06E+03	3.3	3.06E+02	2.13E-02	5.76E+03	.00E+00
54	5.44E+03	3.0	3.06E+02	2.13E-02	5.13E+03	.00E+00
55	1.62E+02	.1	2.10E+01	3.07E-03	1.41E+02	.00E+00
56	5.53E+01	.0	2.75E+01	3.35E-03	2.78E+01	.00E+00
57	1.97E+01	.0	6.88E+00	1.95E-03	1.28E+01	.00E+00
58	3.21E+01	.0	9.53E+00	2.17E-03	2.26E+01	.00E+00
59	7.78E+01	.0	3.08E+01	4.58E-01	4.66E+01	.00E+00
60	1.78E+02	.1	1.53E+02	1.55E+01	1.04E+01	.00E+00

TOTAL STRAIN ENERGY = 1.814E+05

9 2 1 2 5 0 1 0 3 3 4

APPENDIX E

ANALYSIS OF LOADING IMPOSED ON TRANSPORTERS

The object of the analysis presented in this Appendix is to determine the estimated loads imposed on the transporters used to support the waste retriever.

Five cases are examined as follows:

Case I	When operating; no wind loading and no snow loading
Case II	When operating with wind loading
Case III	When operating with wind loading and with snow loading
Case IV	When operating and experiencing an earthquake
Case V	When moving from tank to tank

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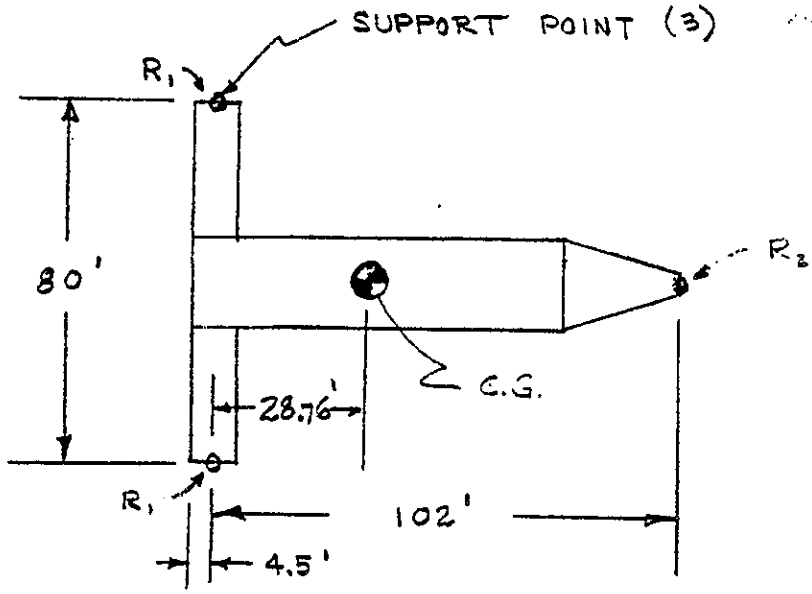
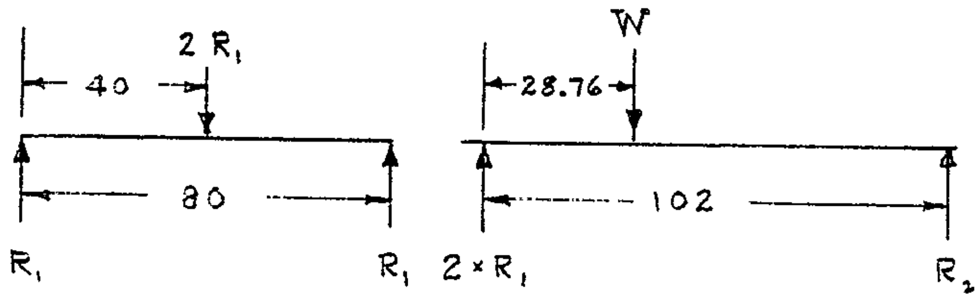
BY Ma! DATE 4-21-77 SUBJECT REACTION LOADS AT SUPPORT POINTS APPENDIX E SHEET NO 1 OF 6
CHKD. BY ______ DATE ______ JOB NO. 5004

CASE I - OPERATING ; NO WIND LOAD ; NO SNOW LOAD





$$R_1 = \frac{W}{2} \times \frac{73.24}{102} = 0.359\ W$$

$$R_2 = W \times \frac{28.76}{102} = 0.282\ W$$

$$W = 754{,}100\ \text{LB.}$$

$$R_1 = 0.359 \times 754{,}100 = 270{,}720\ \text{LB}$$

$$R_2 = 0.282 \times 754{,}100 = 212{,}655\ \text{LB}$$

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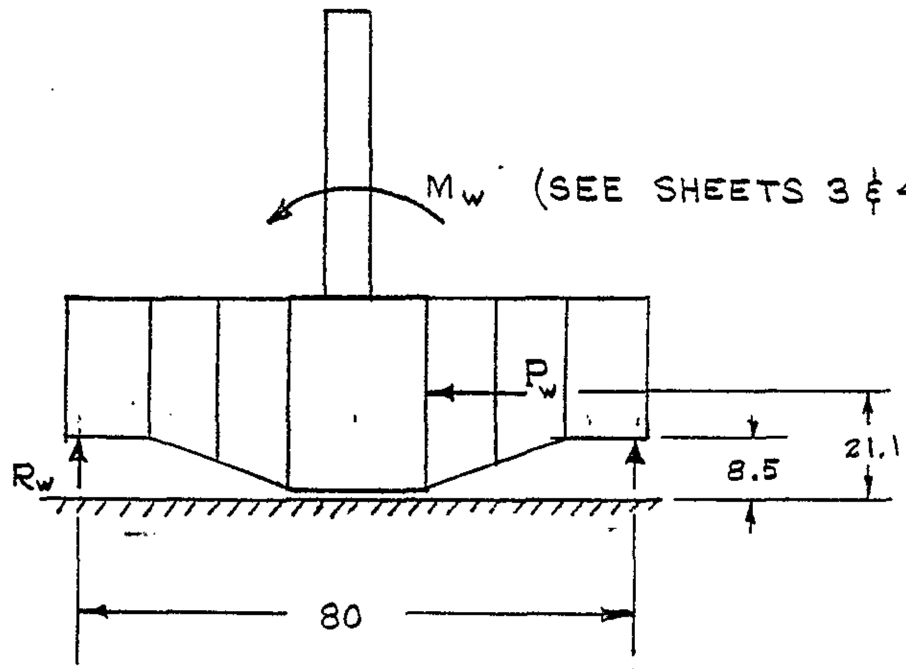
CASE II – OPERATING ; WITH WIND LOAD , WIND DIRECTION NORMAL TO LENGTH OF STRUCTURE.

OVERTURNING MOMENT RESISTED ONLY AT OUTBOARD SUPPORT POINT , i.e. BY R_w

$$R_{II} = R_1 + R_W$$



$$R_W = \frac{M_w}{80} = \frac{529.9 \times 10^3}{80} = \underline{6,625} \text{ LB}$$

P_w = 42,105 LB. (SEE SHEET 4)

$$R_{II} = R_1 + R_W = 270,760 + 6,625 = \underline{277,385} \text{ LB}$$

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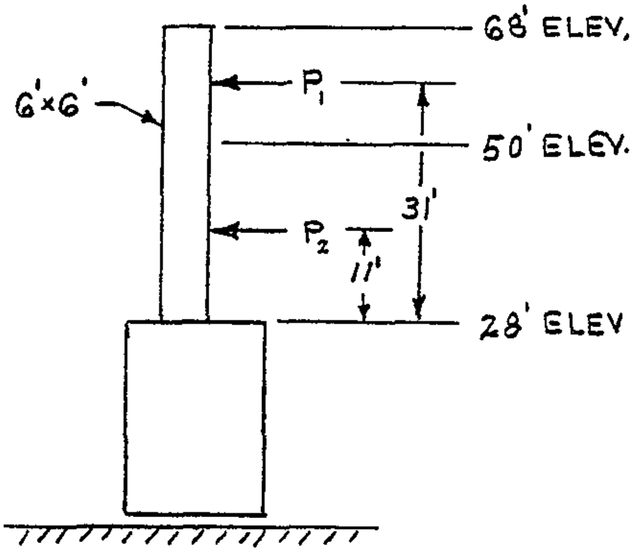
WIND PRESSURE AT HANFORD

HEIGHT LESS THAN 30' — 15 p.s.f.
" 30' TO 49' — 20 "
50' TO 99' — 25 "

FROM UNIFORM BUILDING CODE, 1976, TABLE 23-F & FIG. 4

MINING BOOM TOWER



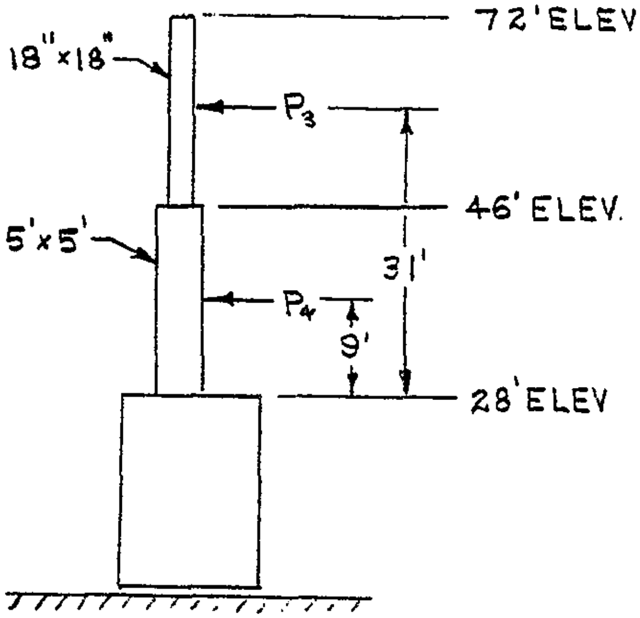
$P_1 = 6\,(68-50) \times 25$

$P_1 = 2{,}700$ LB.

$P_2 = 6\,(50-28) \times 20$

$P_2 = 2{,}640$ LB.

MATERIAL ELEVATOR TOWER



$P_3 = 1.5\,(72-46) \times 25$

$P_3 = 975$ LB

$P_4 = 5\,(46-28) \times 20$

$P_4 = 1800$ LB

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CHKD. BY ____ DATE ____ WIND LOADING JOB NO. 5004

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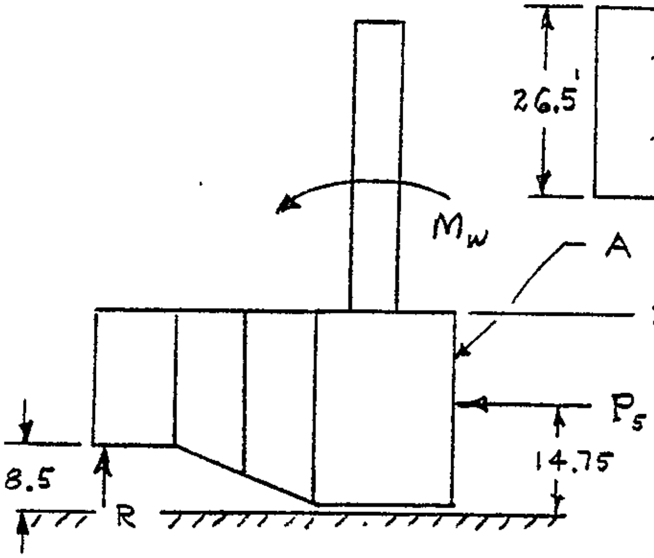

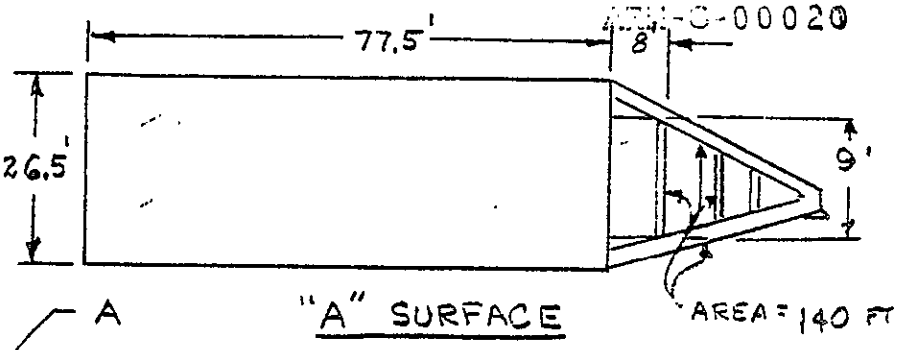

$$AREA = 26.5 \times 77.5 + 8 \times 9 + 140$$
$$= \underline{2,266} \ FT^2$$

$$P_5 = 15 \times 2,266 = \underline{33,990} \ LB$$

MOMENT RELATIVE TO GROUND

$$M = P_1(28+31) + P_2(28+11) + P_3(28+31) + P_4(28+9) + P_5(14.75)$$

$$= 2700 \times 59 + 2640 \times 39 + 975 \times 59 + 1800 \times 37 + 33,990 \times 14.75$$

$$= (159.3 + 103.0 + 57.5 + 66.6 + 501.4) \times 10^3 \ FT. LB.$$

$$= \underline{\underline{887.8 \times 10^3}} \ FT. LB.$$

$$P_W = \Sigma P = 2700 + 2640 + 975 + 1800 + 33,990$$

$$= \underline{\underline{42,105}} \ LB$$

$$\bar{z} = \frac{M}{P_W} = \frac{887.8 \times 10^3}{42.105 \times 10^3} = 21.085 \ FT$$

MOMENT RELATIVE TO PLANE OF SUPPORTS

$$M_W = P_W(21.085 - 8.5)$$
$$= 42,105 \times 12.585 = \underline{\underline{529.9}} \times 10^3 \ FT. LB.$$

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CASE III — OPERATING + WIND LOADING + SNOW LOAD

R_{III} = REACTION AT OUTBOARD SUPPORT

$$W_{SNOW} = 37,920 \text{ LB}$$

$$\bar{X}_{SNOW} = \frac{77.5}{2} = 38.75 \text{ FT} \quad \text{(FROM LEFT END)}$$

$$R_{III} = R_{II} + \frac{W_{SNOW}}{2}\,\frac{102-(38.75-4.5)}{102}$$

$$= 277,385 + \frac{37,920}{2} \times \frac{67.75}{102}$$

$$= 277,385 + \underbrace{12,595}_{R_{SNOW}} = \underline{289,980} \text{ LB}$$

CASE IV — OPERATING + SEISMIC LOAD

R_{IV} = REACTION AT OUTBOARD SUPPORT

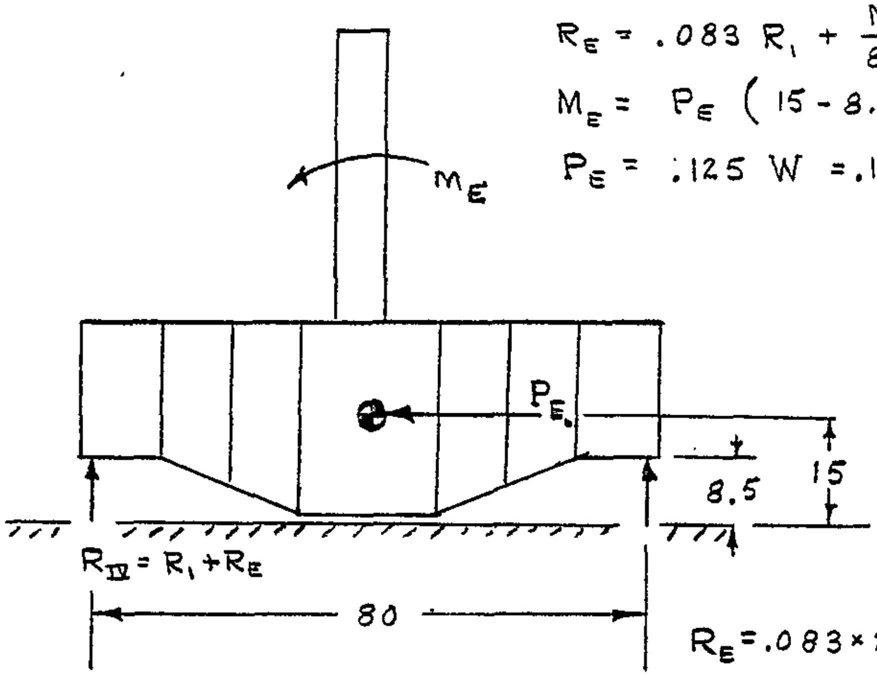
$g_H = .125\ g$; $g_V = .083\ g$ { FROM "HANFORD PLANT STANDARDS SDC-4.1, DESIGN LOADS FOR STRUCTURES"

$R_{IV} = R_1$ (FOR CASE I) $+ R_E$

$$R_E = .083\ R_1 + \frac{M_E}{80}$$

$$M_E = P_E\,(15 - 8.5) = 6.5\ P_E$$

$$P_E = .125\ W = .125 \times 754,100 = \underline{94,260} \text{ LB}$$



$$R_E = .083 \times 270,760 + \frac{6.5 \times 94,260}{80}$$

$$= 22,473 + 7,659 = \underline{30,130} \text{ LB}$$

$$R_{IV} = 270,760 + 30,130$$

$$= \underline{\underline{300,890}} \text{ LB}$$

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BY mas DATE 4-27-77 SUBJECT REACTION LOADS AT SUPPORT POINTS

CHKD. BY .... DATE ....

SHEET NO 6 OF 6

JOB NO. 5004

CASE V – MOVING FROM TANK TO TANK

$R_{1-V} = 0.359\ W$ } SEE SHEET 1

$R_{2-V} = 0.282\ W$

$W = 652,090$ LB

$R_{1-V} = 0.359 \times 652,090 = 234,100$ LB

$R_{2-V} = 0.282 \times 652,090 = 183,890$ LB

HORIZONTAL FORCE WHEN MOVING ON A GRADE.

<u>1% GRADE</u>

$P_{H-1} = .01 \times 652,090 = 6,520$ LB.

<u>5% GRADE</u>

$P_{H-5} = .05 \times 652,090 = 32,600$ LB.

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APPENDIX F

BACKGROUND INFORMATION

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F.1 FIRE-RESISTANT HYDRAULIC FLUID

Characteristics of Pydraul 29-E-LT hydraulic fluid and comparative data for fire-resistant hydraulic fluids (from Monsanto Industrial Chemicals Co., Bulletin number IC/FF-30 and IC/FF-47.

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Pydraul "E" series 2

0020

	PYDRAUL® 10-E	PYDRAUL 29-E-LT
PHYSICAL PROPERTIES		
Appearance	Clear Blue Liquid	Clear Blue Liquid
Spec. Gravity 25/25°C.	1.085—1.095	1.090—1.110
Neutralization No. (mg KOH/g) max.	0.25	0.35
Moisture (max.) %	0.10	0.15
VISCOSITY		
Centistokes @ 100°F.	10.0 cs	30.9 cs
@ 210°F.	2.4 cs	7.9 cs
SSU @ 100°F.	60 SSU	145 SSU
@ 210°F.	35 SSU	52 SSU
Absolute SSU @ 100°F.	60.5 SSU	158 SSU
(SSU x Density) @ 210°F.	35 SSU	54 SSU
Pour Point	−70°F.	−45 °F.
Bulk Temp. Max. (continuous operation)	175°F.	175 °F.
Boiling Point °F. at 760 mm Hg	707°F.	500 °F.
Coefficient of Thermal Expansion per °F.	0.00044	0.00040
Specific Heat BTU/lb./°F. @ 77°F.	0.42	0.39
Thermal Conductivity BTU/hr./ft./°F.	0.047	0.0757
Vapor Pressure mm Hg @ 200°F.	0.002	0.002
Bulk Modulus (Room Temp. 1000-6000 psi)	328,000	370,000
Rust Test ASTM D-665	Pass	Pass
Foam Test ASTM D-892	Pass	Pass
Solubility in Water	Negligible	Negligible
FIRE RESISTANCE TESTS		
Factory Mutual Spray Test. Test fluid sprayed at 1000 psi through orifice, passing through flame of propane torch.	Fail	Pass
Factory Mutual Channel Iron Test. Test fluid sprayed at 1000 psi through orifice, onto hot channel iron at 1300°F.	Fail	Pass
Hot Manifold Test (Federal Test Method Std. 791). Test fluid dripped on at 1300°F.	Intermittent flashing but does not propagate to pan below.	Intermittent flashing but does not propagate to pan below.
Factory Mutual Approval. FM	No	Yes

Fire-resistance Advantages of Pydraul
Pydraul fluids protect hydraulic equipment and personnel with *permanent* fire protection. Pydraul fluids contain no water to evaporate and do not leave a flammable residue. During their many millions of machine hours of use, Pydraul fluids have been accidentally sprayed over molten metal, through electrical arcs, into flames and sparks. They pass all of the important ignition tests for fire-resistance.

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COMPARISON OF PROPERTIES

The many properties most important to good hydraulic fluid performance are shown in Table 3 and Table 4. Petroleum oil is included as a reference fluid. The differences between each type of fire-resistant fluid can be readily seen. The tables are a general classification; there are various differences within each category, but these general properties are representative of each type. When specifying a fire-resistant fluid, the supplier should always be consulted for his product's specific recommendation for the application.

Physical Properties

As Table 3 shows, all fire-resistant fluids are heavier than petroleum oil. The degree of difference is shown by their density. Because of this, a fluid starvation can occur at the pump inlet if the system was not designed for a fire-resistant fluid. It is easily avoided. Increasing the line size on the pump suction or refitting with a flooded suction will usually prevent pump starvation from a heavier fluid. If an extreme "high lift" condition cannot be avoided, supercharging the pump may be necessary. Filtration of fluid in the suction line should always be avoided and a 50 to 60 mesh strainer (no finer) should be used to protect the pump.

The "VI" (viscosity index) of fire-resistant fluids varies according to type. Straight synthetic fluids have a low VI; synthetic base fluids are intermediate viscosity; the VI of water glycols is quite high. (Emulsions are non-Newtonian liquids; they show a different viscosity in motion than at rest; viscosity index cannot be measured.)

The VI of a fluid is usually not critical unless the system temperatures range from very low (<40°F) to very high (>175°F). Within each category of fluids, a range of viscosity index is available. Depending on operating conditions, it may be necessary to select a grade with lower or higher viscosity to ensure satisfactory low temperature pumpability and/or adequate high-temperature viscosity for good pump lubrication.

Vapor pressure, the measure of volatility, is very important from the standpoint of pump performance as well as fluid maintenance. Operating temperatures above 150°F with the water-base fluids cause excessive water evaporation. This creates a tendency to vaporize at the pump inlet, resulting in pump cavitation. This water make-up control is covered later in the fluid maintenance section.

All fluid types offer corrosion protection in their liquid phase, but with water-containing fluids there is still a need for better vapor phase corrosion inhibitors. Vapor phase rusting usually occurs in the reservoirs and the rust particulates falling into a system can damage pumps and cause erractic valve operation. Maintaining adequate fluid level in the reservoir is the best way to avoid vapor phase corrosion; proper filtration can help to prevent rust particle damage.

The storage stability of all these types of fluids is good except for emulsions. Emulsions will separate into three phases (oil, emulsion, water) upon standing. The degree of separation and the time lapse before separation starts, depends upon the particular formulation or brand. Even when emulsions are stored at room temperature, most suppliers recommend drum rolling before the fluid is put into a system. If the emulsion has been stored at low temperatures, high speed stirring is recommended before the fluid is used.

TABLE 3

PHYSICAL PROPERTIES

	Petroleum Oils	Synthetic Fluids	Synthetic Base Fluids	Water Glycol Fluids	Water-Oil Emulsions
Density	0.85-0.9	1.09-1.2	1.02-1.07	~ 1.05	~ 0.95
Viscosity Index	High	Low	Intermediate	High	Non-Newtonian
Vapor Pressure	Low	Low	Low	High	High
Corrosion Resistance					
Liquid Phase	Good	Good	Good	Good	Good
Vapor Phase	Fair	Fair	Fair	Fair to Poor	Fair to Poor
Storage Stability					
Room Temperature	Good	Good	Good	Good	Requires Care
Low Temperature	Good	Good	Good	Good	Poor

Functional Properties

Lubrication characteristics vary markedly between synthetic fluids (and petroleum oils) and water-base fluids. The significance of this difference depends on the type of pump used, the pressure and the temperature. As shown in Table 4, water-base fluids are generally not recommended above 1800 psi and in many cases 1500 psi is the practical limit. Operating temperatures with water-base fluids should be controlled in the range of 120°to 130°F for best performance. A high of 150°F is the maximum since heat leads to excessive water evaporation and aggravates the tendency to vaporize at the pump inlet. Synthetic fluids may be used at pressures up to 5000 psi with no sacrifice in pump life when compared to petroleum oil. The ceiling of 225°F set as the maximum fluid temperature for synthetics is only because at this temperature the viscosity of most fluids is reduced to a point where film strength approaches what is marginal for good pump lubrication. The synthetic fluids have thermal stability well in excess of 225°F so pump life, not temperature, is the factor to consider.

The type of pump used in a hydraulic system may also limit the choice of fire-resistant fluid used. Though all types of fluids can be used in vane and gear pumps, the outlet pressure of axial piston pumps must be derated 30-40% when used with water-base fluids; radial piston pumps should not be operated with water-base fluids at all. Synthetic fluids, however, may be used with both these types of piston pumps.

Most common metals of construction are compatible with all types of fire-resistant fluids. Aluminum should not be used for load bearing surfaces with any of the fire-resistant fluids. Other exceptions are shown in Table 4.

Compatibility with Seals, Packings, Hose Materials: The most common elastomers used for seals and hoses are neoprene and buna N since these two synthetic rubbers are compatible with petroleum oil. Both water-glycol and water-oil emulsion fluids are compatible with these elastomers and this is a significant advantage when converting an operating hydraulic system to a fire-resistant fluid. Synthetic fluids soften and swell both neoprene and buna N and these elastomers are particularly unsuitable for dynamic seals (cylinder packing, pump shaft seals) when these types of fluids are to be used. When converting an oil-operated system to an all synthetic or synthetic base fluid, it is highly advisable to replace dynamic seals with seals made of swell resistant elastomer. Viton is the most common. Seals of Viton (or other compatible elastomers) will prevent premature failure of the seals and forestall excessive fluid leakage. Static seals generally need not be changed, since swelling tightens them and serves to prevent leakage. However, static seals should also be replaced with seals of a compatible elastomer when components are disassembled for maintenance.

For hydraulic hoses, buna N and neoprene are the most common hose liner materials; they are satisfactory for use with water glycols and water-oil emulsions. Synthetic and synthetic base fluids require hose linings of Butyl, EPR or nylon.

Paints commonly used in the reservoirs of petroleum oil systems are not compatible with synthetic, synthetic base or water glycol fluids. These types of fluid cause peeling of oil-resistant paint and contact results in fluid contamination and erratic valve performance. When converting a system, reservoirs should be stripped of paint before contact with any synthetic or water-glycol fluid. Reservoir repainting is not necessary but if this is done, an epoxy-base paint should be used.

When converting from petroleum oil to a fire-resistant fluid, or from one type of fire-resistant fluid to another, the fluid supplier should be consulted for recommendations on proper procedures. USA Standard B 93.5, 1966 also gives complete details on conversion procedures. Copies can be obtained from the National Fluid Power Association, Thiensville, Wisconsin 53092.

Filtration of hydraulic fluids is extremely important and can dramatically affect pump life. Synthetic, synthetic base and water glycol fluids tend to be more detergent than petroleum oil or emulsions; they will carry dirt and wear particles in suspension rather than sinking them to the bottom of the reservoir. Therefore, good filtration is important to maintain long component life. All of the hydraulic fluids are easily filtered and a pressure side filter of 10 micron or smaller is advisable for any industrial hydraulic system regardless of the fluid used. The only precaution in the filtering is that absorption-type filters that operate with active earths or clay should not be used with water-base fluids since their corrosion inhibitors and wear additives may be removed.

General costs for the various types of fluids are given in Table 4 and cover a wide range. Fire-resistant fluids are in the higher range as can be expected. It is usually necessary to pay a premium for safety since fire prevention in any form costs money. Fire-resistant hydraulic fluids, while more expensive than petroleum oil, can save many times their cost when a hydraulic line breaks and sprays fluid on an ignition source. Nearly all insurance companies recognize this and adjust their rates accordingly. If fire-resistant fluids are not being used in a hazardous area, a check with the insurance company may reveal the price paid for petroleum oil is higher than its cost per gallon.

TABLE 4

FUNCTIONAL PROPERTIES

	Petroleum Oil	Synthetic Fluid	Synthetic Base Fluid	Water Glycol	Water-Oil Emulsions
Lubrication					
Max. Pressure	Up to 5000 psi	Up to 5000 psi	Up to 5000 psi	Moderate	Moderate
Recommended Operating Temperature	200°	175°-225°F	150°-200°F	150°F (max.)	150°F (max.)
Compatibility					
Common Metals	Good	Good*	Good*	Exclude Zn,* Cd, Mg	Exclude Mg*
Common Seals	Neoprene Buna N	Viton[1] Silicone Teflon[1] Fluorel[3] Butyl EPR	Viton Silicone Teflon Fluorel Butyl** EPR**	Neoprene Buna N Butyl[2]	Neoprene Buna N
Common Hoses	Neoprene Buna N	Butyl EPR Nylon	Butyl EPR Nylon	Neoprene Buna N Butyl	Neoprene Buna N
Paints	Oil Resistant	Special (epoxy base)	Special (epoxy base)	Special (epoxy base)	Oil Resistant
Filtration, Min. Size, microns	< 10	< 10	< 10	< 10	< 10
Fluid Cost/ Gallon	\$0.50-\$1.25	~ \$8.00	~ \$5.50	~ \$4.00	\$0.75-\$2.00

* Aluminum is not recommended for load bearing surfaces with any fire-resistant fluid.
** Satisfactory under certain use conditions – fluid supplier should be consulted.
[1] Trademark of DuPont de Nemours & Co.
[2] Trademark of Enjay Chemical Co.
[3] Trademark of Three-M Co.

FIRE RESISTANCE

The safety of any fluid is directly related to its relative fire resistance. This leads to the question: What is fire resistance and how is it measured?

The term fire-resistant is used to describe these fluids rather than non-flammable or fire proof. All commercial fire-resistant fluids can be made to burn under highly artificial or unusual conditions. The key points to consider when evaluating fire resistance are ease of ignition and propagation. These are practical measures of a fluid's safety in use.

Fire-resistant fluids are more difficult to ignite and once ignited, flames have much less tendency to spread from the ignition source. This is not the case with petroleum oils.

There are many tests used to measure fire resistance. Private organizations, industrial companies, military branches, government departments, insurance underwriters and cooperating combinations of these groups have done much work to measure fire resistance and to standardize the tests.

Although many individual tests exist, they may be classified into the following small number of groups:

- Flash and Fire Points
- Autogenous and Spontaneous Ignition Temperature
- Ignition of Spray and Flame Propagation
- Hot Metal Surfaces and Molten Metal
- Wick Flammability
- Special and Combined

The fire resistance of hydraulic fluids is a difficult property to define and measure. Several facets must be considered and all factors weighed to assess their relative importance in a given application. The fire resistance of a given fluid is then a considered judgment in the light of all these factors. Generally fire resistance tests are empirical simulative tests which compare known and unknown fluids. Each test is designed to bear some relationship to an actual hazard. Most ratings therefore are arrived at by qualitative visual observations.

Typical fire resistance values for commercial types of industrial fire resistant fluids are compared with petroleum oil in Table 5.

Except for large operations that can justify their own fire test facilities, a fluid user usually looks for guidance from the supplier's fire tests. Insurance underwriters will approve or rate fire-resistant fluids and may require they be used in certain installations.

FLUID MAINTENANCE

In normal use, fire-resistant fluids can be divided into two groups for maintenance considerations. As with petroleum oil, straight synthetic and synthetic base fluids are relatively stable and require only simple filtration at the machine to remove solid contaminants. Water-base fluids usually need periodic water make-up and some types require replenishment of additives.

In cases of severe service or accidental contamination, more elaborate maintenance and monitoring programs may be justified if the fluid renewal procedures will allow long-continued use of the fluid and minimum make-up or replacement. Such programs usually require a portable recovery unit that can be moved to each machine or ways to collect fluid and move it to a central processing point. Such programs can be carried out by the user or by a contract reclaimer.

The specific points to observe on maintenance of each type of fluid are as follows:

TABLE 5

FIRE RESISTANCE PERFORMANCE

	Petroleum Oil	Straight Synthetic	Synthetic Base	Water Glycol	Water-In-Oil Emulsion
Flash Point	300-400°F	400-500°F	400-500°F	No ignition until water is evaporated	No ignition until water is evaporated
Fire Point	350-450°F	650-700°F	450-550°F	No ignition until water is evaporated	No ignition until water is evaporated
Spontaneous Ignition Temperature (ASTM D2155)	500-650°F	900-1000°F	750-850°F	800-850°F	650-700°F
Temperature for Ignition on Open Metal Surface	500-900°F	1300-1600°F	1000-1300°F	1000-1200°F	650-1000°F
Wick Type Ignition	Ignites readily, spreads along wick	Difficult to ignite. Does not spread.	Moderately difficult to ignite, does not spread or spreads slowly	No ignition until water evaporates then burns and spreads	No ignition until water evaporates then burns and spreads
Sprays and Streams	Ignites readily, large flame carried along stream and usually continuous burning	Difficult to ignite, local flame by ignition source, self-extinguishing when ignition removed	Moderately difficult to ignite, medium size flame may flash along stream, self-extinguishing when ignition removed	When water present — difficult to ignite, small flame, non-spreading and self-extinguishing. When water content low, burns readily with large flame which spreads.	Similar to water glycol with and without water

F.2 SPECIFICATIONS FOR ROD & CABLE CUTTING TOOL

Manco Model MCE-85 is used on the Rod and Cable Cutting Tool, PaR Drawing No. P-21196-C (Figure 7-26). Data from Manco Industries, Inc. catalog.

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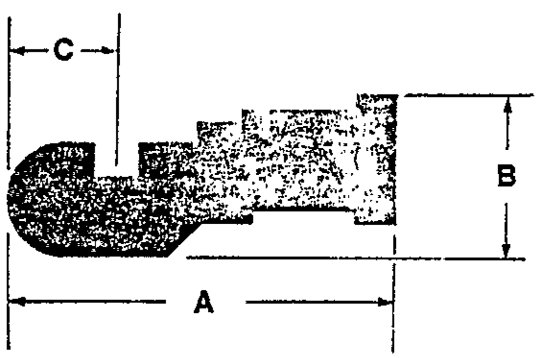
specifications

or MANCO Hydraulic Guillotine Cutting Tools
Note: All top and bottom blades are interchangeable

MODEL OF TOOL AND WEIGHT WITH ELECTRIC CONTROL SWITCH		BLADE PART NUMERS*	ALUMINUM and Other Non-Ferrous Metals *Not for Very Ductile Alloys	STEEL Low Carbon to 90,000# Tensile, or R/B 91	STEEL High Carbon and Low Alloy to 115,000# Tensile, or R/C 25	STEEL High Alloy to 170,000# Tensile, or R/C 38	STEEL Hardened or Chilled to 240,000# Tensile, or R/C 46	STEEL Reinforcing Rod Deformed	STEEL, STAINLESS, to 170,000# Tensile, or R/C 38	URANIUM, CAST, to 80,000# Tensile	URANIUM, ROLLED, to 170,000# Tensile	TITANIUM 220,000# Tensile	CUTTING TIME WITH STD. 3 G.P.M. UNIT (LESS RETURN)
MCE-215	15#	220-102-HD	3/4" Dia. 18.9 MM	3/4" Dia. 18.9 MM	5/8" Dia. 15.7 MM	1/2" Dia. 12.6 MM	7/16" Dia. 11 MM	1/2" Dia. 12.6MM	1/2" Dia. 12.6 MM	3/4" Dia. 18.9 MM	1/2" Dia. 12.6 MM	7/16" Dia. 11 MM	5/8 Second
MCE-220	32#	220-102-HD	1" Dia. 25.2 MM	7/8" Dia. 22 MM	13/16" Dia. 20 MM	3/4" Dia. 18.9 MM	9/16" Dia. 14.2 MM	13/16" Dia. 20 MM	13/16" Dia. 20 MM	1" Dia. 25.2 MM	13/16" Dia. 20 MM	9/16" Dia. 14.2 MM	3/4 Second
MCE-35	44#	35-102-HD	1 1/8" Dia. 28.3 MM	1 1/8" Dia. 28.3 MM	1 1/16" Dia. 26.7 MM	1" Dia. 25.2 MM	13/16" Dia. 20 MM	1" Dia. 25.2 MM	1" Dia. 25.2 MM	1 1/8" Dia. 28.3 MM	1" Dia. 25.2 MM	13/16" Dia. 20 MM	1 Second
MCE-35-HD	44#	220-102-HD	1 1/8" Dia. 28.3 MM	1 1/8" Dia. 28.3 MM	1 1/16" Dia. 26.7 MM	1" Dia. 25.2 MM	13/16" Dia. 20 MM	1" Dia. 25.2 MM	1" Dia. 25.2 MM	1 1/8" Dia. 28.3 MM	1" Dia. 25.2 MM	13/16" Dia. 20 MM	1 Second
MCE-35-SC	72#	35-375-A-HD		1 1/4" Dia. 31.4 MM	1 1/8" Dia. 28.3 MM	1" Dia. 25.2 MM							1 1/2 Seconds
MCE-35-A	74#	35-190-HD	2" Dia. 50.3 MM	1 1/8" Dia. 28.3 MM	1 1/16" Dia. 26.7 MM	1" Dia. 25.2 MM	13/16" Dia. 20 MM	1" Dia. 25.2 MM	1" Dia. 25.2 MM	1 1/4" Dia. 31.4 MM			1 1/2 Seconds
MCE-65-HD	123#	65-156-HD	1 1/2" Dia. 37.7 MM	1 1/2" Dia. 37.7 MM	1 1/4" Dia. 31.4 MM	1 3/16" Dia. 29.9 MM	1 1/16" Dia. 26.7 MM	1 3/16" Dia. 29.9 MM	1 3/16" Dia. 29.9 MM	1 1/4" Dia. 31.4 MM	1 3/16" Dia. 29.9 MM	1 1/16" Dia. 26.7 MM	2 Seconds
MCE-85	240#	85-102-HD	2" Dia. 50.3 MM	2" Dia. 50.3 MM	1 9/16" Dia. 39.3 MM	1 7/16" Dia. 36.2 MM	1 3/16" Dia. 29.9 MM	1 7/16" Dia. 36.2 MM	1 7/16" Dia. 36.2 MM	1 9/16" Dia. 39.3 MM	1 7/16" Dia. 36.2 MM	1 3/16" Dia. 29.9 MM	4 Seconds
MCE-100	413#	100-102-HD	2" Dia. 50.3 MM	2" Dia. 50.3 MM	2" Dia. 50.3	1 13/16" Dia. 45.6 MM	1 1/2" Dia. 37.7 MM	1 13/16" Dia. 45.6 MM	1 13/16" Dia. 45.6 MM	2" Dia. 50.3 MM	1 13/16" Dia. 45.6 MM	1 1/2" Dia. 37.7 MM	5 Seconds

Note: Refer to *Power Units, Valves, and Accessories Section* for illustration of Hot Cutting Extension unit.



	A	B	C
MC-215	10 1/2" 264 MM	4 3/4" 120 MM	3" 75 MM
MC-220	14" 352 MM	5 3/4" 145 MM	3 1/8" 79 MM
MC-35	14 1/2" 364 MM	6 1/8" 154 MM	4 1/4" 107-MM
MC-65	23" 579 MM	9 1/2" 238 MM	6 1/4" 157 MM
MC-85	31 1/4" 786 MM	11 3/4" 296 MM	7 1/8" 179 MM
MC-100	38 1/4" 962 MM	16 3/4" 421 MM	11" 277 MM

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F.3 SPECIFICATIONS FOR HYDRAULIC IMPACT HAMMER

The Rapid-Ram is used on the Hydraulic Impact Hammer, PaR Drawing No. P-21202-C (Figure 7-23).

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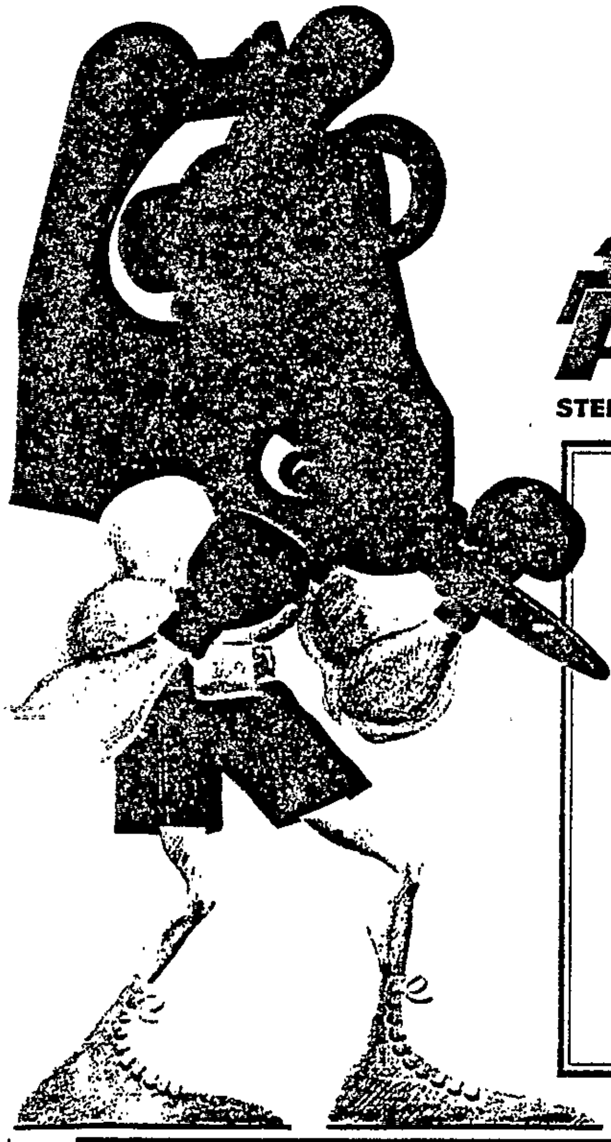
Keep pace...
put a Rapid-Ram™ on your Case!

A breakthrough in design!



ALLIED
STEEL & TRACTOR PRODUCTS, INC.

Meet the light-weight champion of the world... Allied's Rapid-Ram.

Surprisingly inexpensive, it outclasses all comers because its unique rotary design eliminates piston and cylinder, reducing internal wear — a major cause of decreased performance.

What's more, the Rapid-Ram hits faster than comparable hammers — 1250 blows a minute. And it hits harder. Rapid-Ram delivers 250,000 ft. lbs. of impact a minute at only 11 G.P.M. of oil!

Because it's hydraulic, Rapid-Ram needs no air compressor. You'll save on both equipment and fuel. And on maintenance costs too.

Rapid-Ram's noise level is well within O.S.H.A. requirements.

Watch the champ in action — knocking out rock, concrete, curbs, pavement and bridge abutments — and you'll know why this remarkable hydraulic hammer is the undisputed king of its class.

Other features include:

- Quick-change demolition tool.
- Minimum lubrication requirements.
- Shock-resistant mounts protect boom by inhibiting recoil.
- Idle running. Operator can re-position the hammer without the delay of having to shut it off. Unlike other hammers, idle running can't affect the Rapid-Ram.

Specifications

Impact energy per blow	200 ft lbs.
Blows per minute	1250
Impact energy per minute	250,000 ft. lbs.
Weight with mounting bracket	700 lbs.
Required oil flow	11 G.P.M.
Minimum pump capacity	15 G.P.M.
Overall length	57″
Spacing inside mounting bracket	11″
Demolition tools:	
Chisel point, 2½″ diameter, 14″ working length	Standard
Conical point, 2½″ diameter, 14″ working length	Optional
Tamping foot	Optional

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F.4 DATA ON TRACK-TYPE TRANSPORTER

Specifications for a track transporter of the type proposed in the conceptual design.

Picture showing track transporters being used to install a bridge structure in the FFT Facility on the Hanford Reservation.

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OAKLAND, ORE. 97479
TEL: 503-459-2287

ARH-C-00020

VAN DE HEY
TRACK TRANSPORT INC.

THE PEOPLE WHO MAKE BIG THINGS MOVE

SPECIFICATIONS ON MODEL T500 SERIES 4 RATED AT 500 TON

TRANSPORTERS:

POWER: 903 Cummins Diesel
STARTING SYSTEM: 12 Volt
COMPRESSOR: Engine mounted, water cooled, pressure lubricated 12 CFM
TRANSMISSION DRIVE: Torque converter, 3 speed power shift in forward and reverse.
FUEL TANK CAPACITY: 93 gals. Plus additional 100 gals.
(352 liters) (378.5 liters)
CLUTCHES: Oil cooled, hydraulically applied, air released, multiple disc
BRAKES: Air, band-type, oil cooled.
PARKING BRAKES: Spring loaded, air released
CONTROLS: Air steering, air brakes, manual controlled power shift.
INTERMEDIATE ROLLERS: 22 rollers with 5" (12.7 cm) dia. shafts.
TRAVEL SPEED: Up to 1½ mph (2.414 kms./hr)

A.	Center of carbody to outside of track-----------	11'0" (335.28 cm)
B.	Crawler tread width ---------------------------	5'6" (167.64 cm)
C.	Carbody length---------------------------------	9'6" (289.56 cm)
D.	Center of carbody to outside of powerplant------	43" (109.22 cm)
E.	Height to top of track-------------------------	58" (147.32 cm)
F.	Height from ground to top of carbody------------	52" (132.08 cm)
G.	Height from ground to underside of carbody------	22½" (57.15 cm)
H.	Height from ground to lowest point of powerplant	10" (25.40 cm)
I.	Center of carbody to front of track-------------	10'11" (332.74 cm)
J.	Length of track--------------------------------	22'0" (670.56 cm)
K.	Height from ground to botton of powerplant front	22" (55.88 cm)
L.	Height to top of powerplant--------------------	59" (149.86 cm)
M.	Front of powerplant to front of track----------	69" (175.26 cm)

STANDARD EQUIPMENT

**CAB & CONTROLS: Located side of powerplant equipped with heater, defroster, windshield wiper, deluxe seats, lights.*
**GREASE SYSTEM: Central automatic lube system to all grease points on machine.*
**BACK UP ALARM HORN*
**RED FLASHING BEACON: With 4 sealed beam lamps.*
**OPTIONAL EQUIPMENT: Turrets, carriages, saddles, hydraulic jacking systems bunk arrangements as per customer arrangements.*

Because of continuing improvements, Van De Hey Track Transport, Inc. reserves the right to make changes at any time.

BEFORE YOU CALL ANY LOAD "IMPOSSIBLE", CALL VAN DE HEY 503-459-2287.

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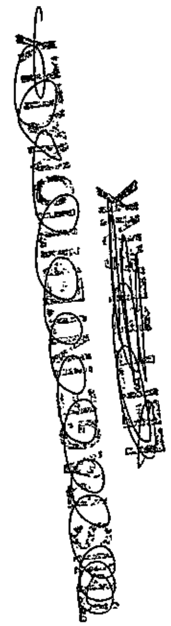

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DIMENSIONS FOR TURRET OPTION ON T500 SERIES 4 MODEL RATED AT 500 TON INTERMITTENT 400 TON CONTINUOUS:

R.	Height from ground to top of turret------------	89 3/8"	(227.01 cm)
S.	Center of carbody to edge of turret------------	120"	(304.8 cm)
T.	Width of turret--------------------------------	113"	(287.02 cm)

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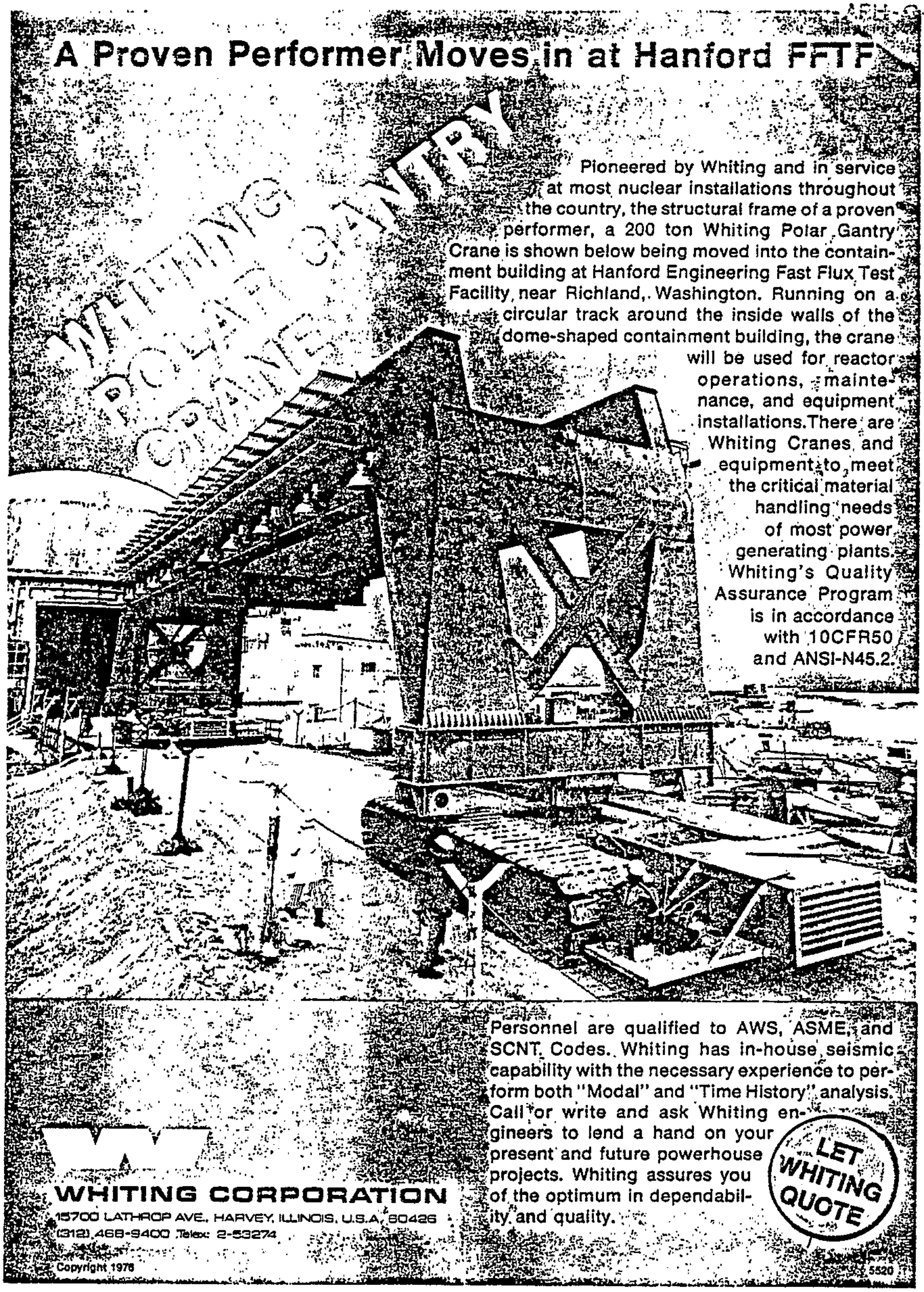

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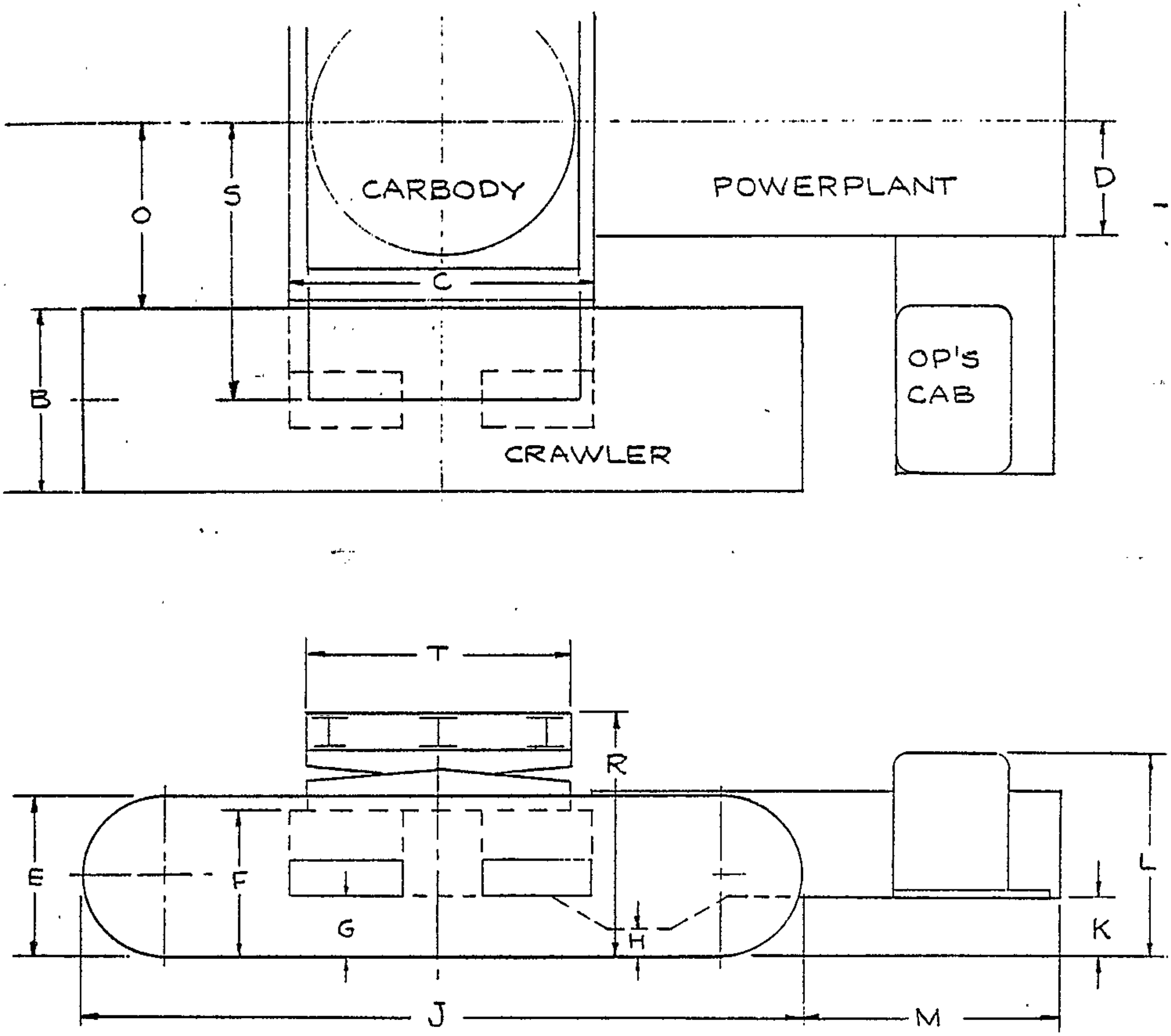

CRAWLER TRANSPORTER
MODEL T500 - SERIES 4

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F.5 SPECIFICATIONS FOR PaR MODEL 1200 FLEXTROL ABSOLUTE POSITION INDICATOR

This indicator is proposed for use in the control system of the conceptual design.

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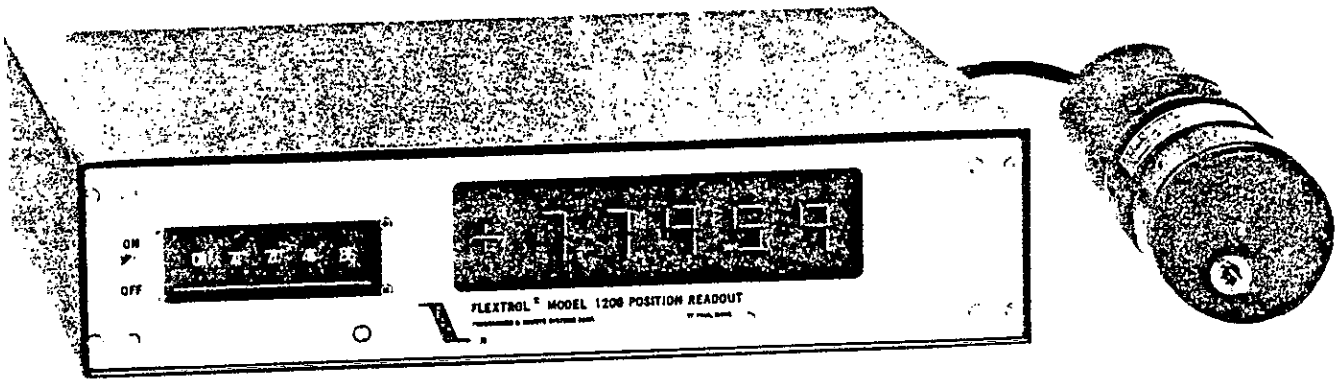
BULLETIN 1200



WITH ZERO OFFSET FOR REFERENCE POINT SHIFTING

Engineered for reliability, low cost and easy maintenance

Features plug-in modules.

For applications such as:

- Machine tool position monitoring
- Inspection equipment gauging readout
- Precision material handling equipment position control and monitoring
- Digital weighing systems requiring tare zeroing

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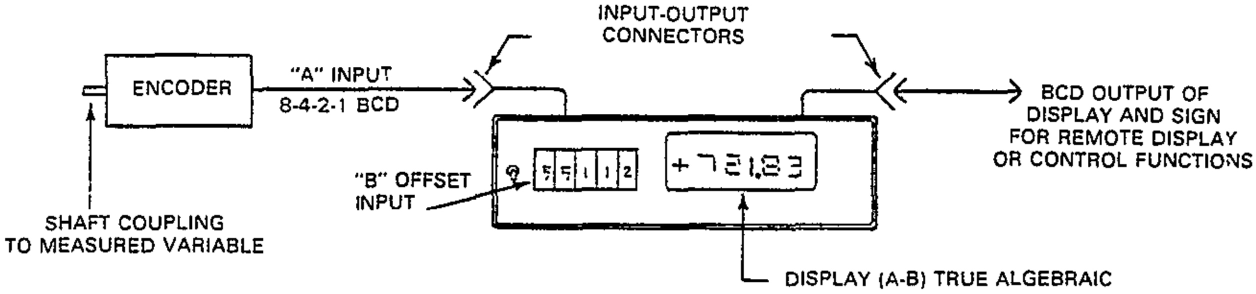
TYPICAL BLOCK DIAGRAM



STANDARD MODEL SPECIFICATIONS

ENCODERS: User supplied (non ambiguous BCD type).

ENCLOSURE: Welded 18 ga. steel, blue wrinkle finish, 3"H x 13"W x 7.25"D.

INPUT: Non-ambiguous BCD, + 5V TTL logic level, 5 or 6 decade 0, + 5VDC @ 100 MA supplied at input connector for encoder use. Input connector Amphenol Series 57; mating unwired plug supplied.

CONSTRUCTION: All-PC card wiring utilizing IC components. PC cards plug into motherboard for simplified maintenance.

POWER: 100-125VAC 60HZ, 25 watts.

OPERATING TEMP: 0-50° C.

CONTROLS: Power on-off, decade offset thumbwheel switches for reference setting (offset from actual encoder input value).

OUTPUT: BCD output connector and mating unwired plug (TTL logic).

OPTIONAL FEATURES:

- Non-standard internal voltage supplies to meet user's encoder requirements.
- Input plug for B reference input in place of thumbwheel switches.
- Non-standard number of decades.

ORDERING INFORMATION:

Model 1200-5-S	5 decade
Model 1200-5-S-O	5 decade with output connector
Model 1200-6-S	6 decade
Model 1200-6-S-O	6 decade with output connector

Specify decimal point location

Call or write for more information on standard and special units.

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F.6 SPECIFICATIONS FOR PaR MODEL 3000 MANIPULATOR

This manipulator is proposed for general maintenance and utility applications in the conceptual design.

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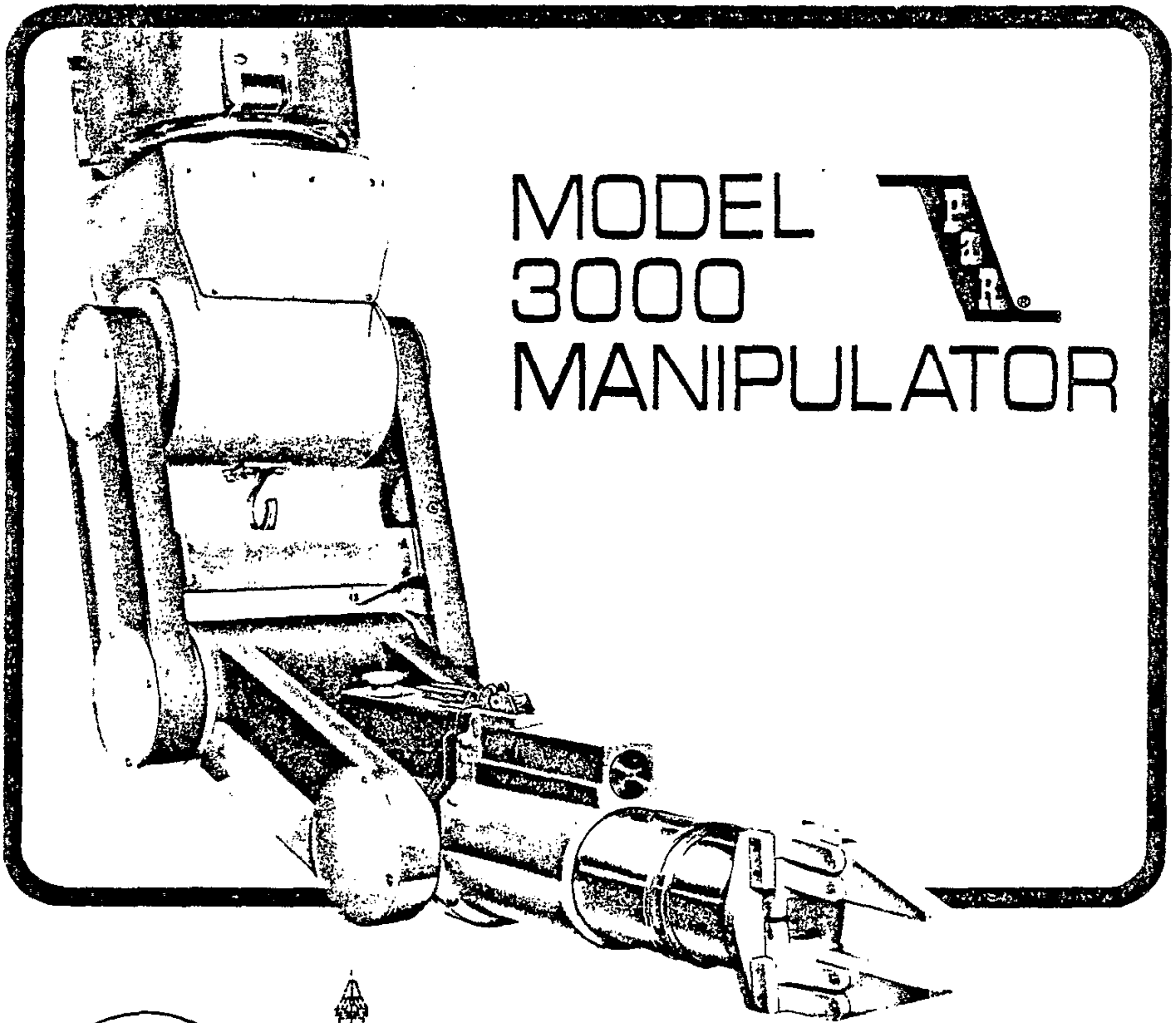
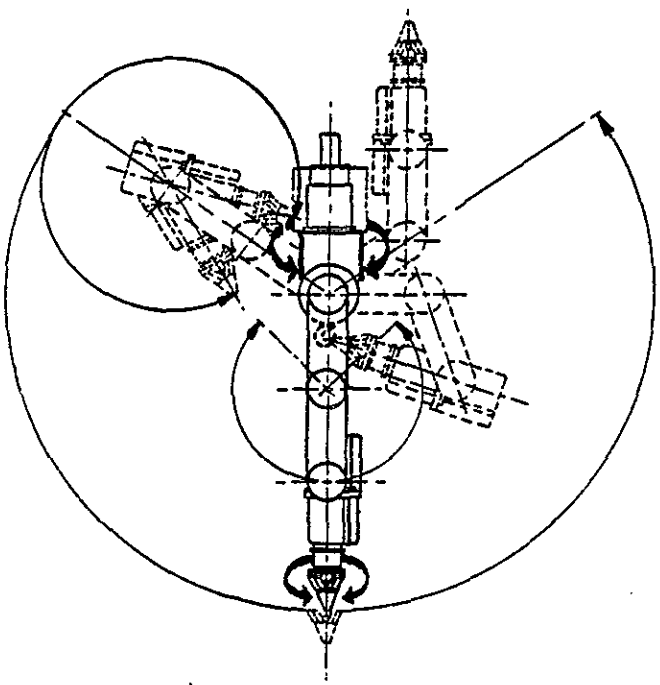


MODEL 3000 MANIPULATOR



GENERAL FEATURES

- All motions are electrically driven and are protected against overload by slip clutches and motor overload relays.
- The manipulator is sealed to allow washdown.
- Corrosion resistant materials and finishes are used on external surfaces.
- The manipulator is compact to facilitate operations in restricted space.
- Unitized "box" construction is used to provide maximum rigidity and external smoothness.
- All wiring is internal to eliminate snagging and to provide an easily decontaminated exterior.
- Access plates are included for easy clutch adjustment and general maintenance.
- Easily adjustable and stable drive chain tighteners are provided on all pivoting motions.
- Hands and tools can be changed remotely by simple push-pull motions. Hands remain fully engaged over their full travels.
- A high load capacity hook is fastened to the shoulder housing. The manipulator hand easily reaches the hook.
- Stepless variable speed control and human engineered control system provide easy, direct operation.

MOTION SPECIFICATIONS

HAND

Parallel Jaw Hand

Travel	5 inches
Force	0-200 lbs.
Velocity (open - close)	18 in./min.

Hook Hand (Note 1)

Travel	3 inches
Force	0-800 lbs.
Velocity (open - close)	5 in./min.

WRIST

Rotation

Travel (both directions)	Continuous
Torque	420 in. lbs.
Velocity	7 RPM

Extension

Travel (In-Out)	4 inches
Force (Push-Pull)	150 lbs.
Velocity	17 in./min.

Pivot

Travel	310°
Velocity	1.2 RPM

ELBOW

Pivot

Travel	270°
Velocity	1.2 RPM

SHOULDER

Pivot

Travel	250°
Velocity	1.2 RPM

Rotation (Note 2)

Travel (Both directions)	Continuous
Torque	2000 in. lbs.
Velocity	3.5 RPM

Velocities given are continuously variable, the values given being the nominal maximums at no load. Normal tolerances on maximum velocities are ±15%. Velocities at rated loads are approximately 0.6 of the no load velocities. Minimum velocities are one-tenth or less of the maximums.

Unless otherwise noted, load capacities are rated for a 150 pound load at the hand with the manipulator elements in any position.

The Model 3000 manipulator weighs approximately 170 lbs.

(Note 1) Optional equipment.

(Note 2) Other shoulder rotation assemblies are available.

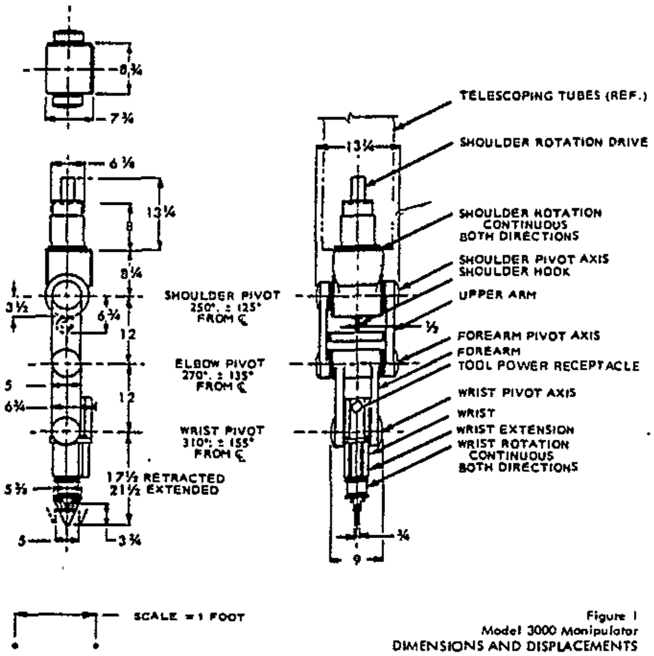


Figure 1
Model 3000 Manipulator
DIMENSIONS AND DISPLACEMENTS

CONSTRUCTION, OPERATION, DESCRIPTION

HAND AND WRIST

Parallel jaw hands, hooks and a wide variety of tools and accessories can be used with the manipulator. A coupling on the wrist assembly allows these to be easily interchanged remotely.

Coupling or uncoupling of a hand or accessory is accomplished by straight line motion of a spring loaded collar on the wrist. Change fixtures for remote operation are available.

Grip force is controlled by an electric clutch. This clutch also provides overload protection. The desired grip force is established by a control knob on the console.

An electrical receptacle is mounted in the wrist housing for use with powered tools.

The wrist assembly housing is made in two sections. Remotely operable throw latches are utilized to hold the two wrist sections together for ease of maintenance and accessibility.

LOWER ARM AND UPPER ARM

The lower arm and upper arm are of continuous "box" construction to give maximum rigidity, inherent sealing, and ease of disassembly. The arms are totally sealed with "O" rings.

Chain tighteners mounted in the arm are externally adjustable, maintain constant settings, and are efficient from friction and wear standpoints.

Access plates are provided on the arm elements for easy inspection and maintenance.

WRIST, ELBOW AND SHOULDER PIVOTS

The motors and drives for these motions are in the shoulder housing. Power is transmitted by roller chains and sprockets in the arms.

Double-face slip clutches are included in each drive to provide overload protection. Although the clutches come preset, they can be adjusted through a removable cover on the shoulder housing.

Within the rated capacity, motions will not move under load with the power off. Dynamic braking on each motor provides smooth and quick stopping.

SHOULDER ROTATION

The shoulder rotation assembly bolts to the top of the shoulder housing and connects to the telescoping tube or other mounting used. An overload slip clutch is included in the drive. The standard shoulder rotation assembly mounts in the inner telescoping tube and can be used with hoist capacities up to 5000 pounds. Rotate drive is remotely removable from tubes with a PaR supplied fixture for ease of maintenance and accessibility. Other shoulder rotating units are available. Among these are flat types for face mounting. Please contact PaR for special requirements.

CONTROL AND ELECTRICAL SYSTEM

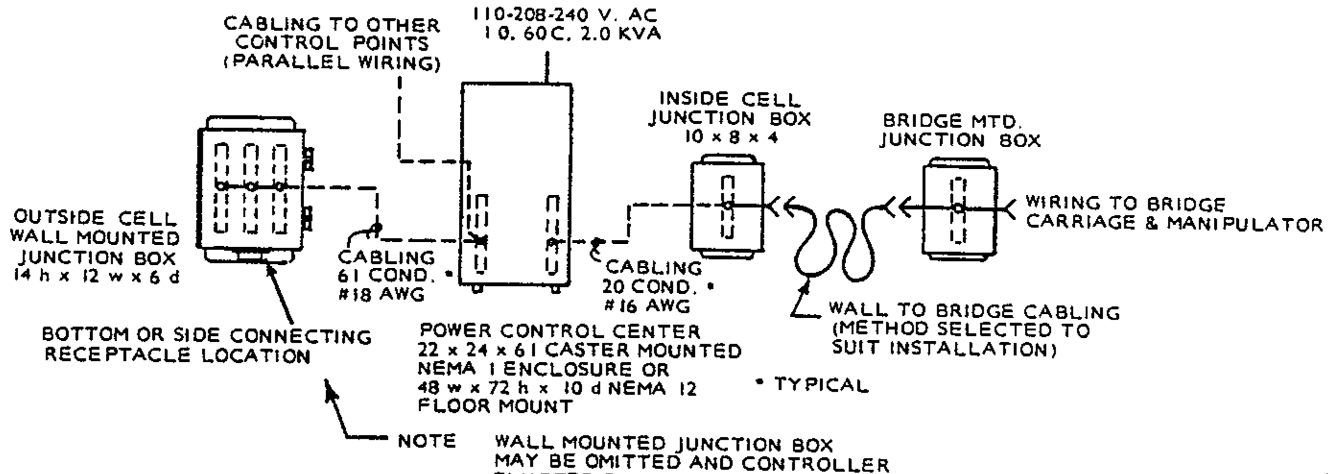


Figure 2
ELECTRICAL BLOCK DIAGRAM

TYPICAL ELECTRICAL SYSTEM

A block diagram of a typical electrical system is shown in Figure 2. Additional control features and accessories are described in the literature on manipulator control and power equipment.

CONTROL CONSOLE

The portable control console shown in Figure 3 can be mounted to wall brackets or placed on a flat supporting surface or caster mounted controller stand. It connects to the power center by a flexible cable terminating in a quick disconnect plug. The top of the console is hinged for easy access and carrying handles are located on each end.

Each motion of the manipulator is controlled by a knob spring centered to the "off" position. Velocities in both directions are proportional to the displacement of the knobs.

Rotary motions are controlled by rotary knobs and the others by sliding knobs. All are flush mounted to minimize accidental movements and to provide most comfortable operation. The console shown in Figure 3 and described below is for a manipulator mounted on a telescoping hoist, carriage, and bridge. Similar arrangements are used for other mounting methods.

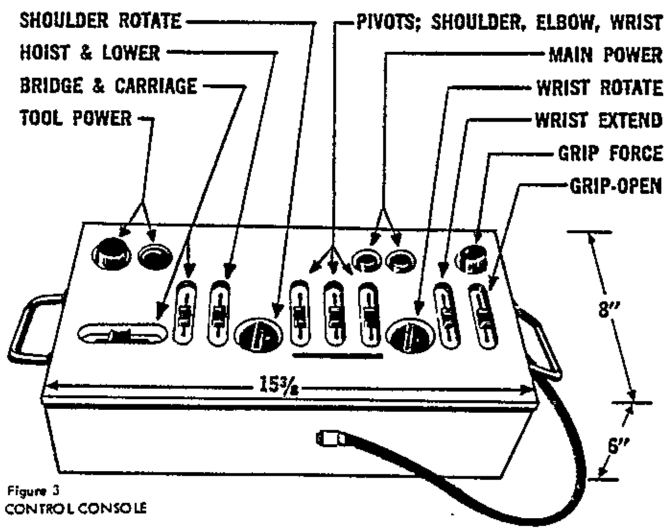


Figure 3
CONTROL CONSOLE

Color coding on the console and on the manipulator provides direct correlation between motions of the two. Thus, movement of a pivot knob toward the "yellow" bar on the controller will move the corresponding manipulator element in the directions of its "yellow" side.

The console provides the necessary controls for grip force, power on-off, and tool power. Additional controls can be added as necessary for a particular installation.

POWER CENTER

The power center is a caster mounted cabinet containing individual panels for each motor control unit. Front and rear doors provide access to these panels. The power center also can be provided as a NEMA 12 floor mounted cabinet with front doors only.

The manipulator can be supplied to operate at either 120, 208 or 240 volts, 60 cycle, single phase. The power required for the manipulator alone is approximately 1 KVA.

All components and terminal points are marked with circuit numbers for quick identification.

All motors are driven by magnetic amplifiers or silicon controlled rectifier amplifiers and are protected by overload relays.

Typical wiring requirements between the power center and the manipulator are shown in the block diagram.

MANIPULATOR WIRING

All motor leads in the manipulator are terminal block connected to allow easy motor installation.

TOOL POWER RECEPTACLE

A receptacle to supply power and control for electric tools is provided in the wrist assembly. Power supplied is 5 amps continuous, 10 amp intermittent, with 115 volts and 80 volts AC for two speed control. Tools used must be of the 115 volt AC-DC universal motor type with wiring modifications so that direction can be controlled at the console.

SIDE WRIST PIVOT

The Model 3000 manipulator can be supplied with a side wrist pivot motion, if ordered with the original manipulator. This motion increases the versatility and coverage of the manipulator.

A. Side Wrist Pivot without Wrist Extension

The Model 3000 Manipulator with this feature is shown in Figure 4. The side wrist pivot motion has a torque of 1900 inch pounds about the side pivot axis and a travel of 220 degrees, ±110 degrees about the center-line. The pivot velocity is continuously variable the same as the other manipulator motions, with a maximum velocity of 0.5 RPM.

An additional control knob is included on the control console for this motion.

The basic load capacity of the manipulator with this motion is 150 pounds.

B. Side Wrist Pivot with Wrist Extension

The Model 3000 Manipulator with this feature is shown in Figure 5. The side pivot motion has a torque of 1900 inch pounds about the side pivot axis and a travel of 180 degrees, ±90 degrees about the centerline. The pivot velocity is continuously variable the same as the other manipulator motions, with a maximum velocity of 0.6 RPM.

Two additional control knobs are included on the control console, one for the side wrist pivot and one for the wrist extension.

The basic load capacity of the manipulator with the combined wrist motions is 120 pounds with the wrist retracted and 100 pounds with the wrist extended. With this wrist assembly the hand cannot touch the shoulder load hook.

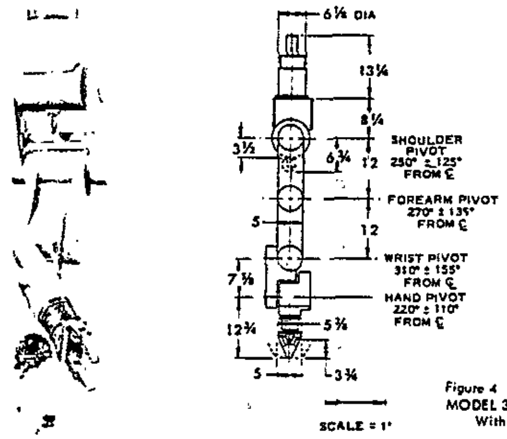


Figure 4
MODEL 3000 MANIPULATOR
With SIDE WRIST PIVOT
(No wrist extension)

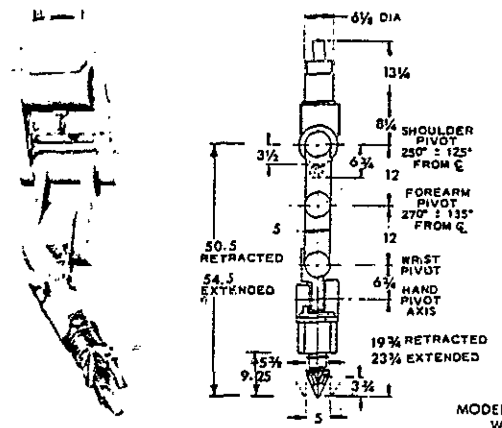
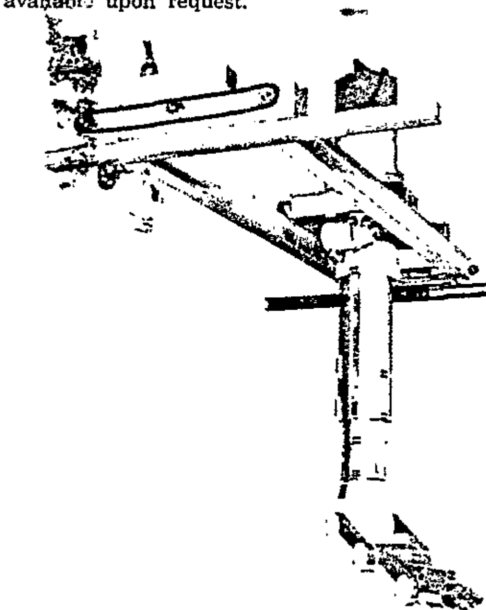
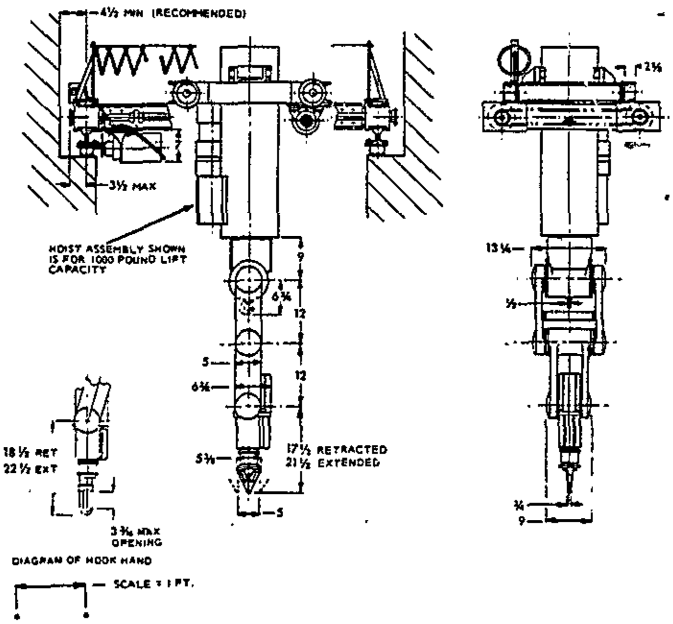


Figure 5
MODEL 3000 MANIPULATOR
With SIDE WRIST PIVOT
AND WRIST EXTENSION

TYPICAL SYSTEM

A typical Model 3000 manipulator, telescoping tube, carriage, and bridge system is shown below. As a convenience in making facilities layouts, standard application drawings are available upon request.





The literature on bridges, carriages and telescoping tubes gives detailed information on this type of mounting. Other mounting arrangements are described in the literature on manipulator systems.

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